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1750-1799 Thunderstorm Impacts, Part 2 of  
Thunderstorms in Northern England  
The Unusual Onset Phase of the 2009 Indian  
Monsoon: Weak Upper Circulation





# The International Journal of Meteorology

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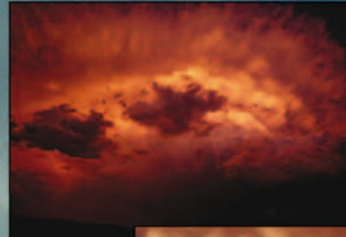
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**THUNDERSTORMS IN NORTHERN ENGLAND,  
1750-1799: PART 2: THUNDERSTORM IMPACTS**

By LANCE TUFNELL

4 Holmcliffe Avenue, Huddersfield, UK.

**Abstract:** A note here about this being concluding part to Thunderstorms in Northern England, 1750-1799: Part 1 in *Int. J. Meteorology*, 36, 363, September 2011. All full titles to abbreviated newspaper references can be located in Part 1.

**Keywords:** Thunderstorm, Northern England, 18th Century, weather impacts.

"The cause of so many horses and sheep being lately killed by lightning, was owing to their seeking shelter under trees, which undoubtedly are conductors to the lightning – This is a matter that should be thoroughly known, in order to warn people who happened to be near trees at the time of thunder how dangerous their situation is".

*Leeds Intelligencer (LI)*, 16 September 1783.

**INTRODUCTION**

A necessary prelude to examining successfully the impact of historical climates is to define accurately the human and environmental conditions of the period(s) in question. During the second half of the 18th century, the population of northern England was much lower than it is today. For example, in 1790 Liverpool had just 55,732 inhabitants (*LI* 23.11.1790), which is around 12 % of its present figure. Similarly, in 1784 Kendal had only 7,571 people (*LM* 15.6.1784; Ward 1999) or about 27 % of its current number. Northern England's smaller population would, however, have been more exposed to thunderstorm risk than are people today. Many would have worked long hours in the open, especially during the main thunderstorm period in summer, and their safety would have been compromised by the metal of the implements they were using. Equally, travellers often had no protection, many being on foot or horseback, as they made journeys that were more protracted than now (e.g. Isaac Fletcher took three days to go from Salford to his home near Cockermouth in 1760: Winchester, 1994). Houses and other buildings would have been much less numerous than today, so there were far fewer places where people could shelter during storms, though this also meant that there were not nearly as many structures for the lightning to strike. However, the value of lightning conductors was only just beginning to be appreciated during the second half of the 18th century, so that buildings would rarely have been protected. Equally, some people may not have been fully aware of the dangers of thunderstorms and medical assistance for victims would often have been rudimentary.

Given this picture, it is not surprising that between 1750 and 1799 lightning and associated floods and hail appear to have had a greater impact on society in northern England than they do today. This view is derived mainly from two Leeds newspapers, the *Intelligencer* and the *Mercury*, and from the *Cumberland Pacquet*. As with the details about thunderstorms, information regarding their impact becomes more abundant after 1766 and it is this period that probably gives the best indication of impact frequencies for the half century as a whole.

## THE IMPACTS OF LIGHTNING

*Deaths and injuries of humans*

Research has identified 88 people who were killed by direct lightning strikes in northern England between 1750 and 1799. This gives an average of 1.76 deaths per year. However, for the 34 years 1766-1799 the annual average rises to around 2.4. Adding to these figures is an incident on 12 May 1770 when lightning destroyed a house near Leeds causing three women to be seriously injured. Two of them were “not expected to live” and must be assumed to have died (*LI, LM 15 May 1770*). There was also a child killed indirectly when burnt in a house fire started by lightning near Bellingham, Northumberland (*AR, GM 1774; LI, LM 19 April 1774*). These 18th century figures for a relatively sparse population in northern England contrast with the situation between 1993 and 2007 when an average of only two individuals a year were killed by lightning over the whole of what is now a much more densely populated British Isles (Elsom and Webb, 2008).

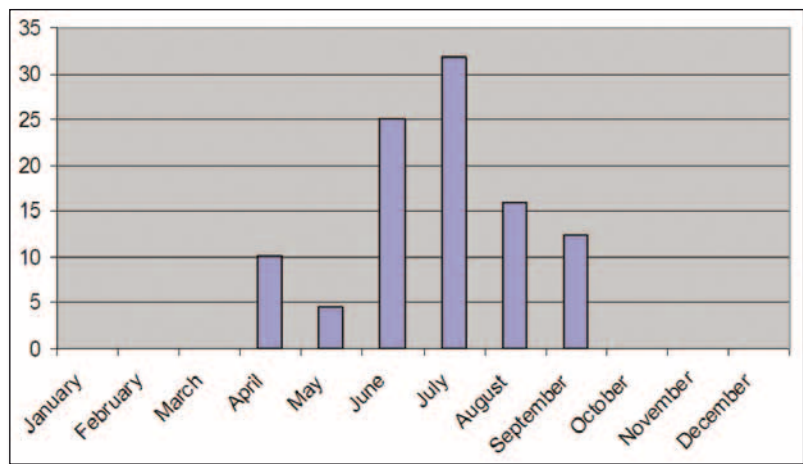


Figure 3. Human deaths from direct lightning strikes in northern England, 1750-1799 (monthly percentages). N=88.

To date, 128 people are known to have been injured by direct lightning strikes in northern England between 1750 and 1799, plus whatever figure might be attributed to those occasions when the number affected was unspecified (i.e. on 24 July 1750 [OS] and 27 July 1775; c.17 April 1789; and on 13 April 1792 and c.16 February 1796: YC 31.7.1750 [OS]; *LM, LI 1, 18 August 1775; LM 21 April 1789; LM 28 April 1792; CP 16 February 1796*). Given these details and assuming that some data sources are yet to be identified, a realistic conjecture would be that around 150 people were injured directly by lightning in northern England between 1750 and 1799. An even higher figure can, however, be suggested if it is accepted that some lightning injuries, particularly those sustained outdoors, may not have been recorded – they were perhaps regarded as an expected countryside hazard with a low news value, especially when they were of a minor nature. In addition, lightning injuries may also have gone unreported because of an area's remoteness and poor communications. Yet, any revised figure for this type of injury seems unlikely to be significantly above that obtained for lightning deaths. It will, therefore, appear very low when compared with modern data (e.g. 1993-1995 figures for the British Isles give a lightning death-injury ratio of 1:22 (Elsom, 1996).

As people in the 18th century spent more time out of doors than we do today, it seems reasonable to assume that this was where most human deaths and injuries from direct lightning strikes occurred. Unfortunately, the sources identified fail to give a precise location for 55 % of people killed and 38 % of those injured. Even so, it is worth noting that where the required details are available, 56 % of deaths and 64 % of injuries were indoors. The picture, therefore, has parallels with that of modern times (cf. Elsom 1996), though the causes will have differed somewhat. For instance, 18th century indoor risk may have been heightened by a greater number of single-storied structures and chimneys coupled with poorer levels of maintenance. However, as today, the element of chance inevitably affected some lightning impacts. For example, during a storm in the Leeds area, on 29 September 1772, lightning killed a man in bed and damaged several items in the room, but passed harmlessly over his wife (*LI 6 October 1772*).

Of the storms that were especially harmful to people in northern England, the worst may have been on 21 September 1775 when lightning killed at least seven and injured 14 (*Poole, 1774-1778; GM 1775; LI, LM 26 September 1775*). Other days when lightning caused more than three deaths and/or injuries to humans were in June 1756, July 1767, June 1768, July 1775, July 1783, June 1789, June 1790, April 1792, July 1792, June 1797, July 1797 and August 1797 (*YC 8 June 1756; AR, GM 1767; Singleton and Hargrave, 1923; GM 1768; LI 28 June 1768; MM 5 July 1768; Poole 1774-1778; LI, LM 1,8 August 1775; CP 3 August 1775; LM, CP 15 July 1783; LI 22 July 1783; LI, LM 7 July 1789; CP 8 July 1789; LI, LM 29 June 1790; CP 30 June 1790; GM 1792; LI 16,23 April 1792; LM 21,28 April 1792; LM 21 July 1792; LI 23 July 1792; AR, GM 1797; LI 3 July 1797, 7 August 1797; LM 8 July 1797, 12 August 1797; CP 8 August 1797*).

As expected, many of the known human deaths and injuries from lightning were during the relatively thundery months of June, July and August, though the September total was strongly raised by the already-mentioned storm in 1775 (Figure 3). Equally, years with high thunderstorm frequencies were quite often times when lightning killed and injured an above-average number of humans, as in 1775, 1783, 1789, 1792 and 1797. Yet, in 1776, 1777, 1791, 1794 and 1796 a large number of thunderstorm days (i.e. over 20 in the year) recorded notably fewer human deaths and injuries from lightning.

Some reports indicate that it may not have been unusual for farmers to carry on working just before and even during a thunderstorm. At times, this may have been the only option, as there was no nearby shelter. On 30 August 1776 a girl was injured by lightning when cutting corn (*Poole, 1774-1778*), while on 18 June 1782 a farmer was killed by lightning while weeding a field (*LI 25 June 1782; LM, CP 2 July 1782*). During a storm on 26 May 1788 people working in fields near Whitehaven “observed the ground near them suddenly ploughed up, and the electric fluid rapidly glancing past them”. Happily, they escaped injury, though the lightning killed three sheep (*CP 11 June 1788*).

*Deaths and injuries of animals*

Here, numbers are harder to determine, as details are often less precise than those for human casualties of lightning. Horses, cattle and sheep appear to have been the groups most affected, but there are also records of several dogs, two cats and two pigs being struck.

The large number of accounts of horses being killed by lightning in northern England over the years 1750-1799 may to some extent be because the animal often had a close relationship with people, so that its death was worth reporting. To date, the number of such deaths identified stands at 56 and there was also one occasion (17.7.1797) when lightning killed “horses in various parts of the East Riding” of Yorkshire (*LI 24 July 1797*).

All but two of the 56 deaths were within the period 1766-1799. These currently-available details suggest that on average one or two horses were being killed by lightning every year in northern England. Some perished along with their riders, while others were struck when grazing. All died in the months May-September, with July proving especially fatal, since it accounted for nearly two-thirds of the deaths. Possibly the worst storms were those on 10-11 July 1783, when more than 11 horses perished (*LI, LM* 15 July 1783). At least four horses were killed by lightning in each of the years 1776, 1787, 1789, 1792 and 1797.

Compared with the list of horses known to have been killed by lightning, that for cattle is slightly fewer (i.e. 50), though there were more occasions (i.e. six) when the number of fatalities was unspecified (*LM* 27 July 1779; *LI* 25 June 1782; *LM, CP* 2 July 1782; *CP* 25 July 1787, 17 September 1788; *GM* 1797; *LM* 3 June 1797; *LI* 24 July 1797). These details suggest that lightning killed rather more cattle than horses in northern England during the study period, the likely average approaching two deaths a year. As expected, fatalities were chiefly in the summer, with July providing almost half the total. The worst years for cattle deaths were 1768 and 1783.

Assessing the number of sheep killed by lightning has proved even more difficult. So far, 70 deaths have been identified, plus three occasions when the number of fatalities was not given (*AR* 1761; *MM* 2 August 1768; *LI* 25 June 1782; *LM, CP* 2 July 1782). That these figures are too low is suggested by the already-quoted passage from 1783 ("many...sheep [have been] lately killed by lightning": *LI* 16 September 1783) and by the total of 70 deaths being largely made up of 40 sheep killed in 1756 during a thunderstorm in Northumberland (*GM* 1756). Although high, this figure is not exceptional for a lightning strike in Britain (*cf.* the death of 91 sheep near Newton Abbot in 2006: Prichard, 2007). It is suspected that the known records of sheep killed by lightning give a picture that is less complete than those for horses and, perhaps, cattle also.

In contrast, the small number of dogs reportedly killed by lightning (i.e. 10) probably approximates reality, as here is another animal whose fate was considered newsworthy, because of its close links to humans. Some of these dogs perished indoors, others when out in the open.

Very few records are known of animals being injured by lightning. Just three horses were specifically reported to have suffered in this way (*LI* 14 August 1759; *LM* 7 July 1789), though on a further occasion "several" were said to have been affected (*LI, MM* 6 May 1755). The only other known lightning injury was to a dog (*LI, LM* 23 July 1776). Again, the numbers may in part reflect how things were recorded, with injury being considered less newsworthy than death, especially if it was minor.

#### Damage to buildings and other structures

Lightning damaged houses and churches in northern England during the study period and, more rarely, lesser structures such as barns, tents, signposts and gallows. In some cases, it damaged the building itself: at other times, it affected mainly its contents. Records also exist of ships being occasionally hit, either in harbour or in coastal waters.

Although recent discoveries about lightning and electricity were mentioned in the newspapers of northern England (e.g. *LM* 3 October 1775, 15 July 1783) and in books (e.g. Bennet, 1789), it seems unlikely that many people would have acted upon advice given. Consequently, reports are known of 143 buildings and (occasionally) lesser structures in northern England being damaged by lightning between 1750 and 1799 (this total does not include reports where the number of buildings affected was merely put at "several"). In the worst cases (i.e. during the storms of 26.7.1750 [OS], 19 April 1757, 27 June 1760, 20 June 1768, 12 May 1770, 31 August 1772, 10 April 1774, 9 August 1776, 7 November 1780 and

30 August 1782) one or more buildings were essentially destroyed by lightning (Chipchase, 1779 *et seq*; *MM* 19-26 April 1757; *AR, GM* 1760; *LI* 21 June 1768; *LI, LM* 15 May 1770; *LI* 8 September 1772; *AR, GM* 1774; *LI, LM* 19 April 1774; *CP* 15.8.1776; *LM* 14.11.1780; *LI, CP* 3.9.1782). At other times, lightning seriously damaged the roofs of domestic buildings, as during storms on 14 March 1769, 8 July 1769, 2 June 1774, 8 June 1776, 5 July 1776, 21 July 1783, 19 August 1783, 8 July 1784 and 18 July 1792 (*LM* 21 March 1769; *LM* 11 July 1769; *LI* 7 June 1774; *LM* 18 June 1776; *LI, LM* 9 July 1776; *LI* 29 July 1783; *LI* 26 August 1783; *LI, LM* 13 July 1784; *LI* 23 July 1792). Likewise, churches were much damaged by lightning on 24 July 1750 [OS], 27 June 1763, 21 July 1766, 28 June 1770, 10 July 1783, 17 July 1789, 17 January 1791, 25 January 1794 and 31 January 1798 (*YC* 31 July 1750 [OS]; Wood, 1751-1754; Hodgson, 1910; *GM* 1763; *LI* 5 July 1763; *AR, GM* 1766; *LI* 29 July 1766, 3 July 1770; *LM* 10 July 1770; *LI, LM* 15 July 1783; *LM* 28 July 1789; *GM* 1791; *LI, LM* 1 February 1791; *LM* 8 February 1794; *LI* 5 February 1798).

On five occasions (in July, 1756; June, 1781; July, 1783; February, 1796; and May, 1797) lightning damaged primarily the masts of ships around the coasts of northern England. However, in another example from July 1783, it split a ship through the middle causing it to sink forthwith (*MM* 3 August 1756; *LI, LM, CP* 26 June 1781; *GM* 1783; *LM* 29 July 1783; *CP* 16 February 1796; *GM* 1797; *LM* 27 May 1797).

Of the 143 buildings and lesser structures known to have been damaged by lightning, around three-quarters were hit during the months June-August, with July easily the worst, having over 40 % of the total (Figure 4). One highly destructive storm occurred on 21 July 1783 in the Newcastle area when lightning "unroofed several houses, and did other considerable damage" (*LI, LM, CP* 29 July 1783). In a storm on 27 June 1789, lightning affected at least six buildings in the Liverpool area (*LM* 7 July 1789; *CP* 8 July 1789). 1789 was also among the worst years for the number of buildings in northern England damaged by lightning (12), though 1775 (nine), 1783 (six + "several") and 1797 (nine + "several") also suffered badly. Other years with at least five buildings struck were 1767, 1769, 1776, 1780, 1791, 1792 and 1799.

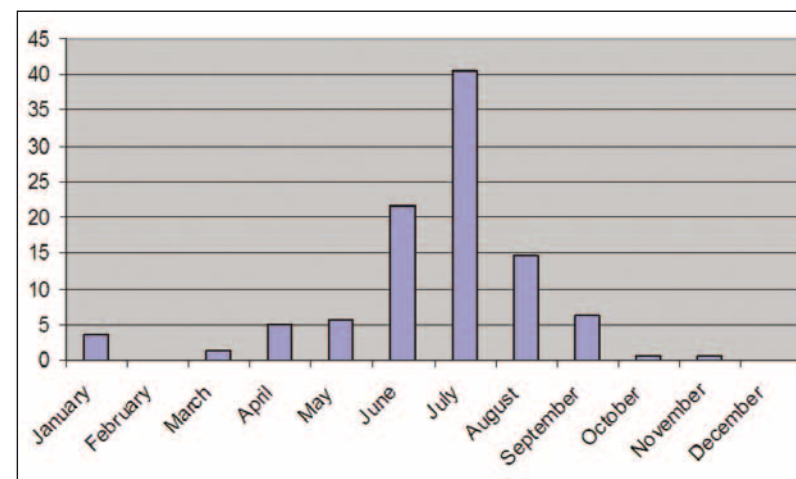


Figure 4. Buildings and lesser structures damaged by direct lightning strikes in northern England, 1750-1799 (monthly percentages). N=143.

*Damage to vegetation*

For an 18th century farmer in northern England lightning was a threat not only to his animals, but also to crops, both in the fields and in storage. Moreover, trees, hedges and gorse on his land could also be struck.

Twelve reports are known of crops being damaged by lightning. Most originated after 1766, though they range from April 1755 (*LI*, *MM* 6 April 1755) to August 1791 (*LI* 6 September 1791). Lightning usually caused damage by setting fire to hay or corn, but on one occasion it “tore up...beans...in the fields” (*LM* 28 October 1777). Crop damage was, however, mentioned less often than the effect lightning had on trees, for this has been identified on 29 days. Reports usually describe how trees were “split...from top to bottom” (e.g. *LI* 23 June 1772) or “shivered to pieces” (e.g. *LM* 15 July 1783). Lightning also set fire to gorse (*LI* 23 August 1791) and damaged hedges (*CP* 18 November 1794; Peat, 1996).

*Geomorphological effects of lightning*

Ten occasions are known from the second half of the 18th century when features variously described as “holes”, “rents”, “furrows” or “apertures” were found in northern England and ascribed to lightning. However, the characteristics of these features were not always clearly described. For example, it was reported that near Halifax, on 29 July 1761, “the ground in many places was forced up [by lightning] as with a plough, in others surprising apertures were made in the earth” (*AR* 1761). Simpler forms are perhaps suggested where accounts merely note a “hole” in the ground (e.g. *LI* 15 May 1770). Equally, some observers gave no indication of aperture size, whereas others commented on their “astonishing depth” (*AR* 1761) or described them as “large” or “great” (e.g. *LI* 12 July 1768; Poole, 1774-1778). The only dimension noted was for an aperture made during a storm in Northumberland on 21 July 1783: it was said to be about half a yard deep (*LM* 29 July 1783). This is very close to the depth of modern apertures described by Campbell (1983).

Reports for two days mention that lightning had split rocks into pieces (*GM* 1756; *AR*, *GM* 1774; *LI*, *LM* 19 April 1774). On a third occasion, they noted how it marked a stone “as if a ball had been shot from a gun against it” (*LM* 29 July 1783). In a fourth example, lightning detached rock from a cliff at Knaresborough (*GM* 1799).

## THE IMPACT OF THUNDERSTORM RAIN

It seems likely that the true impact of thunderstorm rain and floods in northern England during the period studied will remain unknown, because too often observers used the words “several”, “many” and “much”. Only with the comments on human fatalities by drowning is there a modicum of precision. These were all recorded between 1767 and 1799 and averaged about one every three years. The worst storms for such fatalities, each involving at least three deaths, were on 24 July 1768 (Blackburn area) and 23 July 1777 (Holmfirth area) (*LI*, *MM* 2 August 1768; *LI*, *LM* 29 July 1777; *CP* 5 August 1777).

The Holmfirth event and a predecessor two years earlier both feature in the list of thunderstorm floods which killed animals. Thus, on 8 June 1775, “several cattle and horses” died in the Calder (*LM* 13 June 1775), while on 23 July 1777 “many horses, &c. were drowned” in the Holme (*LI* 29 July 1777; *CP* 5 August 1777). Three horses also perished crossing the Wharfe, near Otley, which was swollen by a storm on 18 August 1797 (*LI* 21 August 1797; *LM* 26 August 1797). These misfortunes were, however, eclipsed by the death of over 30 sheep in a thunderstorm flood near Skipton, on 24 September 1774 (*LM* 4 October 1774). Although animal deaths caused by such floods have been identified on fewer days than those on which humans were affected (i.e. four as against six), they clearly involved larger numbers.

Though there were more days (i.e. 12) with reports of damage to buildings by thunderstorm floods, the vague terms often used again make it difficult to know exactly what happened. Once more, the floods of 8 June 1775 and 23 July 1777 appear to have caused some of the worst losses, but buildings were similarly affected in July 1768, December, 1789 and June, 1798 (*LM* 13 June 1775; *LI*, *LM* 29 July 1777; *CP* 5 August 1777; *LI* 26 July 1768, 2 August 1768; *MM* 2 August 1768; *AR*, *GM* 1768; *LM* 5 January 1790; *LM* 9 June 1798; *LI* 11 June 1798). These floods damaged homes, shops and industrial premises (especially dye houses). They also swept away possessions or covered them with filth – for example, a flood at Whitehaven on 12 October 1785 made “furniture and bedding...by the mud and dirt, utterly unfit for use” (*GM* 1785; *CP* 19 October 1785).

The damage to bridges by thunderstorm floods was rather more carefully recorded than that for buildings, though on three occasions (June, 1775, November, 1787 and August, 1792) the number affected was not specified (*LM* 13 June 1775; Peat, 1996; *LM* 8 September 1792). Otherwise, 22 bridges are known to have suffered in this way throughout northern England between 1750 and 1799. The worst thunderstorms for this kind of impact were in July, 1768, June, 1775, July, 1777, November, 1787 and August, 1792 (*MM* 2 August 1768; *LM* 13 June 1775; *LI*, *LM* 29 July 1777; *CP* 5 August 1777; Peat, 1996; *CP* 4 September 1792; *LM* 8 September 1792).

Other structures that were damaged by thunderstorm floods include walls (Murgatroyd, 1781-1804; *LM* 5 January 1790), pavements (*LM* 21 July 1792) and roads (*LM* 1 September 1792). Coal pits were also flooded (*MM* 2 August 1768) and ponds overflowed (Peat, 1996). In addition, there are a few references to floods that apparently affected a variety of structures. For example, on 16 July 1792 thunderstorm floods in the Lancaster area “swept away every obstruction” (*LM* 21 July 1792).

Such floods must also have damaged crops, but the scale of losses cannot be determined, as the only known references to this problem are for storms on 26 July 1768, 24 September 1774, 23 July 1777, 16 July 1792, and 26-27 August 1792 (*AR*, *GM* 1768; *LM* 4 October 1774; *LI*, *LM* 29 July 1777; *CP* 5 August 1777, 24 July 1792, 4 September 1792; *LM* 8 September 1792; Oates and Navickas, 2006).

## PROBLEMS CAUSED BY HAILSTONES ASSOCIATED WITH THUNDERSTORMS

Hail from thunderstorms is known to have damaged buildings, agriculture or the ‘natural’ environment in northern England on 19 days during the period 1750-1799. Building damage was mainly to glass in windows or hot-houses and could be substantial. For example, on 27 July 1775, hail damaged hot-houses and a vinery near Alnwick, breaking more than 360 panes of glass (*LI*, *LM* 8 August 1775). This was also one of several occasions between 1750 and 1799 when thunderstorm hail affected various fruits, field crops and gardens in northern England (Ismay, 1722-1766; *GM* 1762; *LI* 28 June 1768, 18 July 1769; *GM* 1772; *LI* 23 June 1772; *LM* 28 June 1785, 21 July 1792; *LI* 23 July 1792; *GM* 1797; *LM* 5 August 1797).

Thunderstorm hail also damaged trees. Poole (1774-1778) has described how it caused leaves to be “scalopt’d as though cut with sizzers”. Later, on 23 June 1792, it damaged trees in the Cheviots (*GM* 1792; *LM* 7 July 1792). Again, lightning, wind, rain and hail occurred in the Liverpool area on 29 July 1797. Since glass was broken in hot-houses and birds were killed, the hail probably affected trees as well (*GM* 1797; *LM* 5 August 1797). Small birds and poultry were also killed by hail near Newcastle on 20 July 1767 (*LI* 28 July 1767). Almost a year later a report from Haydon Bridge claimed that hail which fell immediately after thunder “did considerable damage, many scores of sheep and several horses and cattle being killed thereby” (*LI* 12 July 1768).

Though surprising, such a claim is not unique. For example, hailstones were reported to have killed several sheep near Stockport in 1733 (Anon, 1990). Whatever the problems of interpretation, it is clear that hail associated with thunderstorms caused a variety of impacts in northern England during the period studied.

## CONCLUSIONS

The main conclusions drawn from the preceding discussion are:

1) The sources identified point to a marked increase of thunderstorms after the first one-third of the half century studied. Future research must attempt to discover if this is indeed what happened or if the true picture has been distorted by the data used. At present, the latter seems more likely, as it is hard to believe, for example, that the 1790s were some 3.6 times more thundery than the 1750s.

2) The number of thunderstorm days identified is probably below the true figure for much of the study period. For example, in 1973 Manley stated that thunder could be heard on 10 to 12 days a year in the Lake District. Yet, known records of thunderstorm days for the 17 years prior to 1767 average only 2.5 per annum in the somewhat larger area that is now the county of Cumbria. Even though the figure rises to 5.9 for the period 1767-1799, it is still well below Manley's values.

3) The impact of thunderstorms on society in northern England was apparently greater during the second half of the 18th century than it is today. Yet, research into things such as frost, snow, floods and wind is showing them to have been even stronger influences on the society of the time. However, all of these need to be more fully researched if we are to have a truly informed view of how weather affected society in northern England between 1750 and 1799.

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## UNUSUAL ONSET PHASE OF THE SOUTHWEST MONSOON 2009: WEAK UPPER CIRCULATION

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**Abstract:** The onset (23rd May) and the advancement of the southwest monsoon season for the year 2009 over the Indian region was unusual. The onset was one week earlier than normal, the progress of the monsoon was delayed for more than 3 weeks, but still the monsoon covered entire India by the 3rd July (12 days earlier than usual). An attempt is made to examine the mean circulation features and dynamics associated with the pre-onset to post-onset period of 2009 and are compared with the corresponding features obtained from a normal monsoon year (2000). Divergence, vorticity and vertical velocity are computed using NCEP reanalyzed daily horizontal wind, over the Asian region (25 °S-30 °N, 40 °E-110 °E) throughout the troposphere for the period 15th May-19th June for both years. For 2009, computed vorticity and vertical velocity indicated the large scale anti-cyclonic circulation in the lower levels over the central and western parts of Indian region, north of 10°N and downward motion is found west of 80 °E from the 5th-15th June. These features were responsible for the prolonged hiatus in the advancement of the monsoon over India during the 2nd and 3rd week of June. During the year 2000 (when monsoon season began at the usual time), computed vorticity and vertical velocity showed cyclonic circulation and upward motion throughout the troposphere during the period 1st June-19th June. To understand the phenomena carefully, the Kinetic Energy for different vertical levels are computed and the time series of Somali Jet (SJ) and Tropical Easterly Jet (TEJ) are obtained. It is found that both weak SJ and TEJ are not favourable to maintain meridional temperature gradient required for the development of monsoon in June 2009.

**Keywords:** Southwest Monsoon, Onset phase, Somali Jet, Tropical Easterly Jet, Monsoon, Circulation, India, vorticity, vertical velocity.

### INTRODUCTION

Principle rainy season for India begins with the onset of southwest monsoon over Kerala coast. Generally 40-45 days time is required to cover the entire country under the influence of monsoon rains. Kerala state, situated in the southwest part of the Indian sub-continent, is the gateway for the Indian summer monsoon. Based on Kerala rainfall, the mean onset date occurs around the 1st June and varies with a standard deviation of 8 days from year to year (Ananthakrishnan and Soman, 1991). The evolution, advancement (active/break or stagnation aspects) and retreat are the most important periods associated with the summer monsoon over India, as they essentially decide the duration of the summer monsoon and the quantity of rainfall over different parts of the country.

It is well recognized that the onset of the summer monsoon is accompanied by distinct changes in the large scale circulation and rainfall distribution over the Indian landmass and surrounding oceanic regions. These include (i) formation and northward movement of cyclonic circulation in the south east Arabian sea, (ii) the northward displacement of upper tropospheric westerly flow to the north of the Himalayas, (iii) organization and strengthening of easterlies in the upper troposphere over peninsular India i.e. establishment of the Tropical Easterly Jet (TEJ) stream (Koteswaram, 1958) and (iv) strengthening and deepening of lower tropospheric westerly jet (Somali jet) over the Arabian Sea (Findlater, 1969). The changes that take place in the atmosphere over the Indian subcontinent at the time of onset of monsoon are described by (Ananthakrishnan and Soman, 1988; Joseph *et al.*, 1994).

The onset date is normally declared based on rainfall, wind, temperature, moisture, cloud pattern, and the state of the sea, *etc.* For a forecaster it is a difficult job to declare the date of onset because all the above parameters are highly variable in space and time. The onset of the South Asian monsoon is associated with both the upper tropospheric temperature gradient between the Himalayas and the Indian ocean (He *et al.*, 1987) and the summer time heating of Tibetan Plateau (Luo and Yanai, 1984; Yanai, *et al.*, 1994). The changes in the meridional gradient of tropospheric temperature can affect monsoon circulation (Webster *et al.*, 1998). The onset date of the monsoon has been defined by several methods in the recent past. Wang *et al.* (2001) introduced a dynamical index based on horizontal wind ( $U$ ) shear at 850 hPa called the circulation index. They recommended that the circulation index computed with the mean difference of the zonal winds ( $U$ ) between the two boxes: one for southern region and the other for the northern region, (i.e. 5°N – 15°N, 40°E – 80°E and 20°N – 30°N, 70°E – 90°E) can be used as the criteria for identifying the onset date. This circulation index describes the variability of the low-level vorticity over the Indian monsoon trough, thus realistically reflecting the large scale circulation. After that Fasullo and Webster (2003) defined the onset date in terms of vertically integrated moisture transport derived from reanalysis datasets. As per their discussion the inter-annual variation in the onset date modestly agreed with reality. Prince *et al.* (2007) defined the onset and withdrawal date of Indian summer monsoon based on meridional gradient of tropospheric temperature gradient. The date of onset of effective monsoon and the length of monsoon period over sub-humid Indian region has been studied by (Subash *et al.*, 2011). However, nothing in the definition can give any indication about the occurrence of drought or deficit rainfall.

Over the Indian Subcontinent, the meridional gradient of tropospheric temperature gradient changes sign seasonally (He *et al.*, 2003). In the summer, there are hotter temperatures over Asian and colder temperatures over the Indian ocean (i.e. the meridional temperature gradient) produces zonal wind with easterly vertical shear due to thermal wind balance. This shear is actually the difference of zonal wind between 200 hPa and 850 hPa over the Indian monsoon region and is used as an index measure of the strength of the monsoons (Li and Yanai, 1996, Goswami and Xavier, 2005). A weakening of the meridional gradient of upper tropospheric temperature will reduce the easterly vertical shear of the zonal wind and reduce the monsoon rainfall. Using the monsoon shear index criteria, strong and weak monsoon years were determined and 1979, 1983, 1987, 1992 were categorized as weak monsoon years (Webster *et al.*, 2002). In the recent decade 2002, 2004 and 2009 were rather drought monsoon years. In strong monsoon years the southwesterlies towards east Africa are enhanced and in weak monsoon years there is a reversal of the wind vectors. This is because the changes in winds between the monsoon extremes occur in the regions where major upwelling occurs. The southwest monsoon precipitation is not spread uniformly in time. There are active and break cycles. Monsoons have two prominent quasi-periodic phenomena having periods of around 15 days (10-20 day mode) and the other around 40 days (30-50 day mode). Krishnamurti and Ardanuy (1980) found that the arrival of the pressure ridge of the 10-20 day mode at 75 °E in the 20-30 °N zone breaks the monsoon situation. If the break condition persists for a longer duration, drought conditions result.

Causes of large scale failure of southwest monsoon have also been investigated by many workers. The important role played by the mid-latitude circulation was first pointed out by Ramaswami (1958) who suggested that the elongation of mid-tropospheric westerly trough into India was associated with dry spells/breaks. Raman and Rao (1981) suggested that an intense west Asian blocking ridge was the initiator of prolonged breaks.

Krishnamurti *et al.* (1989) had suggested that such a blocking high was one of the important factors leading to the drought of 1987. It is also noted that most of the droughts happen to be El-Niño years. Yasunari (1987) has shown that the Asian blocking high is a feature of developing stage of El-Niño. In addition to ENSO, Gadgil *et al.* (2003) pointed out that the Equatorial Indian Ocean Oscillation (EQUINO) play a critical role in the Indian summer monsoon. Further, it is found that each drought is associated with unfavourable phases of either ENSO or EQUINO (Gadgil *et al.*, 2004). It is known that for the year 2002 and 2009 there were both El Niño and EQUINO which are unfavourable in June, but all of India's rainfall in June 2002 was 7 % in excess whereas in June 2009 it was at a deficit of 48 %. Therefore, there is need to investigate the factors responsible for this large deficit in spite of one week early onset (23rd May). Therefore, in the present study an attempt is made to examine the mean circulation features and dynamics associated with the onset phase of summer monsoon seasons over India for the year 2009. It is important to note that rainfall during southwest monsoon 2009 could not be predicted by any of the coupled ocean atmosphere model of leading prediction centres in the world. Therefore, in the present study, day to day variations are intended to be investigated in the large scale circulation patterns during the onset phase of the southwest monsoon in 2009.

#### DATA AND METHEODOLOGY

In the present study the authors use daily horizontal wind ( $u, v$ ), and temperature ( $T$ ) data over the southeast Asian region (25 °S-30 °N, 40°E-110°E) throughout the troposphere for the period 15th May-19th June from NCEP reanalysis (Kalany *et al.*, 1996). Since the NCEP data are available only for standard pressure levels, cubic spline technique is used to interpolate the data at every 50 hPa interval. Vertical component of relative vorticity ( $\zeta = \partial v/\partial x - \partial u/\partial y$ ) and horizontal divergence ( $D = \partial u/\partial x + \partial v/\partial y$ ) are the two important parameters for understanding the dynamics of the system. From the direction and magnitude of vertical velocity ( $\omega$ ), the atmospheric situation can be diagnosed. Therefore,  $\zeta$ ,  $D$  and  $\omega$  are computed over the southeast Asian region from surface up to 100 hPa. For computing vertical velocity ( $\omega$ ), kinematic method is used which assumes that total divergence is zero in the unit vertical column, so a correction factor (O'Brien, 1970) is introduced to correct ' $\omega$ '. The correction to the divergence at a level is considered to be its absolute value (Naik and Salvekar, 2004). Further, kinetic energy of different pressure levels are also computed.

As mentioned earlier, two prominent features of establishment of southwest monsoon are the SJ and TEJ. Therefore, time series of wind speed over (i) the Somali jet region (EQ-10°N, 40°E-60°E) at 850 hPa and (ii) the TEJ region (EQ-15°N, 65°E-95°E) at 150 hPa are also prepared from the 15th May-19th June.

#### THE INDIAN MONSOON AND ITS BEHAVIOUR IN THE LAST DECADE

The monsoon is a manifestation of the seasonal variation of the Tropical Convergence Zone (TCZ) in response to the seasonal variation of the solar radiation. The large scale monsoon rainfall over the Indian region is associated with TCZ. The northward movement of the TCZ from the equatorial Indian Ocean in late May or early June is associated with the onset phase of the monsoon. The onset phase also involves the low level synoptic scale systems (e.g. lows, depressions, MTC *etc.*) moving across the Indian monsoon zone (Ding and Sikka, 2006). The northward movement of TCZ and the occurrence of synoptic scale disturbances, in the Bay of Bengal and the Arabian Sea, which move towards India's mainland play critical roles in the maintenance of continental TCZ. In short, performance of monsoon seasons depends on the oceanic TCZ and continental TCZ. Thermodynamic features and characteristics of convection over the Arabian Sea during pre-onset, onset and post-onset phases were studied by Rao and Aksakal (1994) using MONEX data.

The information of the onset dates and the performance of monsoon in the last decade (1999 to 2008) are presented in Table 1. It can be seen that the monsoon season has a large variability in the last decade.

Table 1. Onset dates and performance of the monsoons in the last decade.

| Year | Onset Date | Monsoon Performance |
|------|------------|---------------------|
| 1999 | 25 May     | Normal              |
| 2000 | 1 June     | Normal              |
| 2001 | 23 May     | Normal              |
| 2002 | 29 May     | Drought             |
| 2003 | 8 June     | Normal              |
| 2004 | 18 May     | Drought             |
| 2005 | 6 June     | Normal              |
| 2006 | 26 May     | Normal              |
| 2007 | 28 May     | Above Normal        |
| 2008 | 31 May     | Normal              |

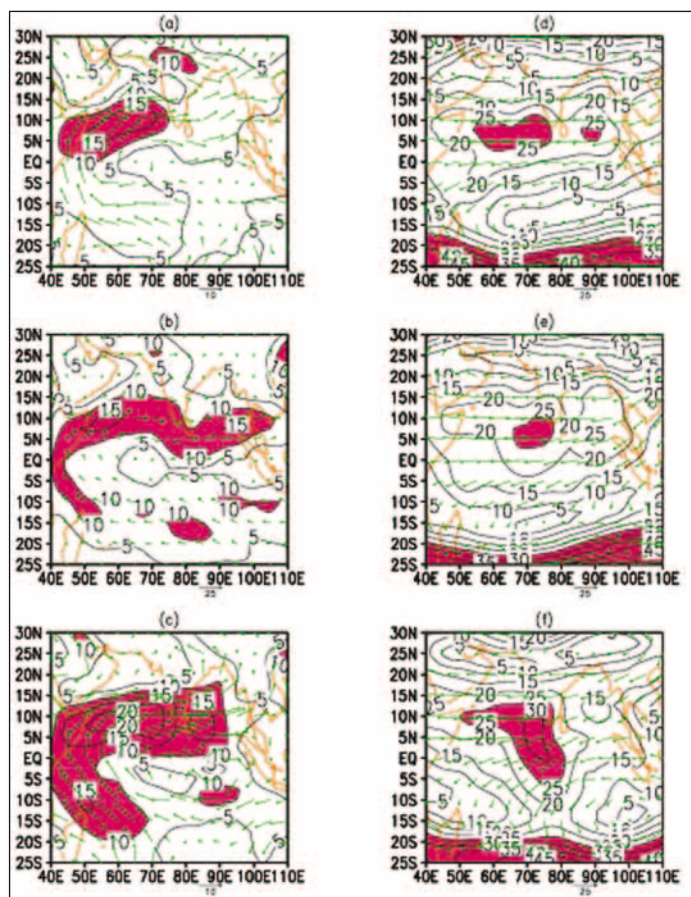


Figure 1. Horizontal wind (m/s) for the year 2000 during pre-onset, onset and post-onset pentad at 850 hPa (a-c) and 150 hPa (d-f).

To study the unusual behaviour of the Onset Phase of 2009, it is required to compare the three dimensional circulation with that of normal monsoon years, or of mean climatology. June is the month for setting the monsoon over the Indian region. As per IMD, the mean onset date is the 1st June. Since 1891, the earliest onset took place on 7 May 1918 and delayed onset took place on 22 June 1972. The onset date used by Raju *et al.* (2005) is the mean onset (1st June) while preparing the climatology of pre-onset, onset and post-onset periods of the 52 years (1948-1999) under study. Since monsoon progress depends on active/break cycles of 15 days (10-20 day mode), it was considered that a 15 day period starting 5 days prior to the onset date would be considered. Therefore, all the parameters, (wind, temperature and moisture) as discussed by Raju *et al.* (2005) are computed for the normal monsoon years of this decade. It is noticed that the circulation and temperature field for the year 2000 is comparable with that of 52 years climatology over the southeast Asian region. Further, it is found that strong cross-equatorial flow and intense westerlies over the Arabian Sea are responsible for the evolution process of the summer monsoon across this region (15°S-45°N, 30°E-120°E). These features are seen for the year 2000. Hence, circulation features during Pre onset phase, Onset phase and Post onset-phase for the year 2009 are compared with that of year 2000. For this purpose the 15 days period of both years are considered as shown in Table 2.

Table 2. Period considered for pre-onset, onset and post-onset phase for the years 2000 and 2009.

|                  | Year 2000            | Year 2009            |
|------------------|----------------------|----------------------|
| Onset Date       | 1st June             | 23rd May             |
| Pre-Onset Phase  | 24th May to 29th May | 16th May to 20th May |
| Onset Phase      | 30th May to 3rd June | 21st May to 25th May |
| Post-Onset Phase | 4th to 8th June      | 26th to 30th May     |

## MONSOONS IN 2000 AND 2009

### Large Scale Circulation and Dynamics

Horizontal wind distribution for lower levels (850 hPa) and upper levels (150 hPa) during the average of the pentad pre-onset, onset and post-onset period (as defined in the last section) are shown in (Figure 1). Significant changes occurred in the large scale atmospheric circulation over the region from pre-onset to post-onset period. Strengthening of strong wind flow is seen in the South Central Arabian Sea (EQ-15°N, 45°E-72.5°E) at 850 hPa during pre-onset period with a maximum of around 15 ms<sup>-1</sup> (Figure 1a) whereas the study of Raju *et al.* (2005) showed low-level strong wind in the Central Equatorial Indian Ocean EQ-5°N and 70°E-90°E with a maximum of 15 ms<sup>-1</sup>.

The upper tropospheric flow at 150 hPa shows that the TEJ develops during the pre-onset to post-onset phase (Figure 1d-f) with a maximum of 25 ms<sup>-1</sup> in the equatorial region between 65°E-85°E. Magnitude is slightly underestimated as compared with 52 years climatology but the horizontal domain having maximum easterly wind is more or less same.

Horizontal distribution of relative vorticity ( $\zeta$ ) and vertical velocity ( $\omega$ ) for pre-onset, onset and post-onset period are obtained from surface for tropopause level and are presented for the middle day for each period pentad. Therefore,  $\zeta$  and  $\omega$  for the 27th May, 1st June and the 6th June for different vertical levels are presented in Figure 2(a-h), Figure 3(a-h) and Figure 4(a-h) respectively. During pre- to post-onset period, computations of  $\zeta$  and  $\omega$  indicate that large scale cyclonic vorticity is present in the lower troposphere to the mid-troposphere over central Arabian Sea and adjacent west coast of India.

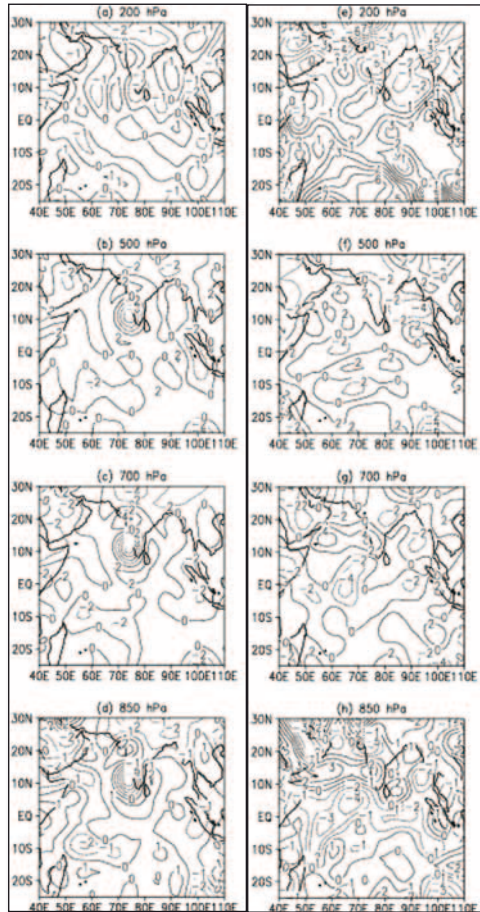


Figure 2. Horizontal distribution of vertical velocity (a-d) in  $10^{-3} \text{ mb s}^{-1}$  and vorticity (e-h) in  $10^{-5} \text{ s}^{-1}$  at levels 850, 700, 500 and 200 hPa on 27th May 2000 (pre onset).

On the 27th May, (pre-onset pentad) cyclonic circulation is seen in the central Arabian sea from 500-850 hPa (Figure 2f-h) with a maximum  $\zeta \sim 4 \times 10^{-5} \text{ s}^{-1}$  and strong upward motion with a maximum  $\omega \sim -6$  to  $7 \times 10^{-3} \text{ mb s}^{-1}$  in the southwest coast of India at 700 hPa (Figure 2c). During the onset period, the region of cyclonic vorticity is extended from the centre of the Arabian Sea to Head Bay, but the magnitude of these parameters is less: i.e. positive vorticity with a maximum of  $\zeta \sim 3 \times 10^{-5} \text{ s}^{-1}$  from the southern tip of India to head Bay is noticed on the 1st June (Figure 3h).

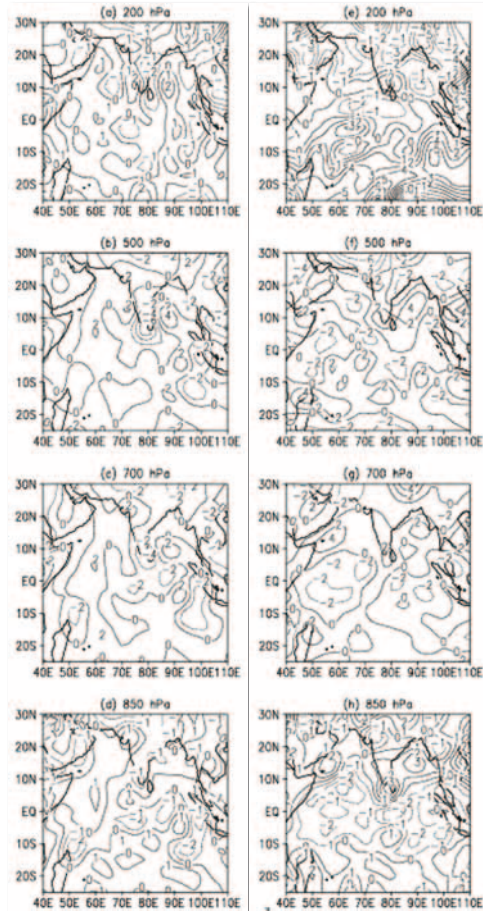


Figure 3. Same as Figure 2 except on 1 June 2000 (onset).

Also,  $\omega \sim -4 \times 10^{-3} \text{ mb s}^{-1}$  (Figure 3b-c) at 500-700 hPa is seen in the southern tip of India. In the post-onset week period, the magnitude is increased at 850-500 hPa with a maximum  $\zeta \sim 6$  to  $7 \times 10^{-5} \text{ s}^{-1}$  near  $20^\circ\text{N}/85^\circ\text{E}$  (Figure 4f-h) and  $\omega \sim -7 \times 10^{-3} \text{ mb s}^{-1}$  in the west coast of the Indian region (Figure 4b-d). These features indicate an active cycle during the onset phase.

The horizontal wind features of the monsoon flow during average stages of the pentad pre-onset, onset and post-onset periods (Figure 5a-f) are shown for the year 2009 at 850 hPa and 150 hPa.

© Rosemary Mann  
Lenticular clouds over Yorkshire, UK.

© **Lee Johnson**

7 October 2011

This image has to be one of the most spectacular photographs IJMet has published. Beautiful, colourful, magical.





© Rosemary Mann  
Lenticular clouds over Yorkshire, UK.

In the pre-monsoon period, strong wind is in the equatorial region (5°N/85°E) at 850 hPa (Figure 5a), which is abnormal in comparison to 2000. During the onset pentad the wind is enhanced: up to 15 ms<sup>-1</sup> in the central equatorial Arabian Sea (Figure 5b) which indicates the occurrence of the SJ and hence favourable conditions for the arrival of the annual monsoon. In Findlater's analysis (Findlater, 1971), the low-level jet along the southeast trade is oriented southeast to northwest over the southern Indian Ocean. During 2009, it possesses nearly zonal orientation along EQ-5°N. The SJ over the northern Arabian Sea is identified with two branches over the Arabian sea in the Findlater's Climatology. Of these, only the more southern branch near 10°N is identified during 2009 for a three week period from onset. The maximum wind in Findlater's climatology is around 55°E/10°N, while during 2009, the maximum wind is around 60°E/5°N.

In the south-central Bay, maximum winds are up to 18 ms<sup>-1</sup> (Figure 5b). During post-onset, low-level wind was suddenly reduced with a maximum of just up to 12 ms<sup>-1</sup> (Figure 5c) whereas during 2000, the maximum winds were up to 20 ms<sup>-1</sup> (Figure 1c). In the upper troposphere (150 hPa), easterlies are extremely weak from both pre- to post-onset period, particularly in the central equatorial Indian Ocean during pre-onset pentad. Winds are about one and half times more than the norm in the north of 22°N in the pre-onset period.

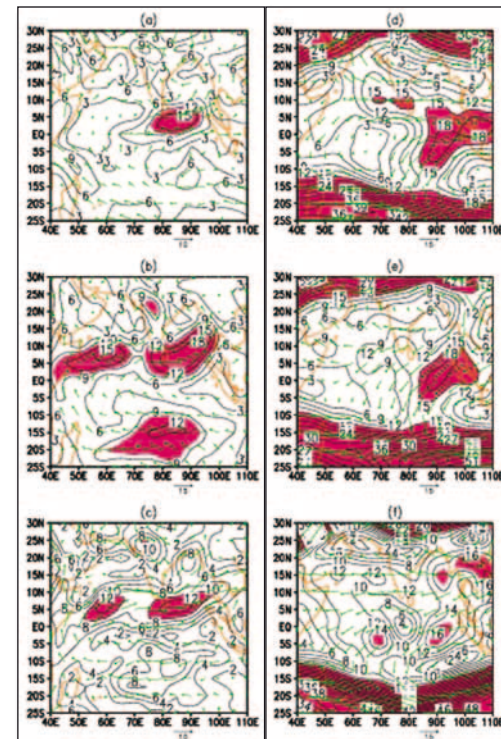


Figure 4. Same as Figure 2 except on the 6th June 2000 (post-onset).

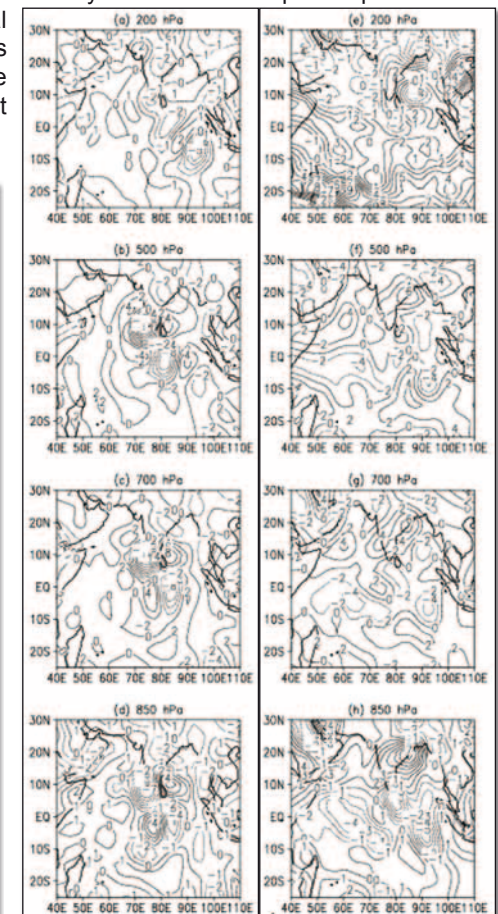


Figure 5. Same as Figure 1 except for the year 2009.

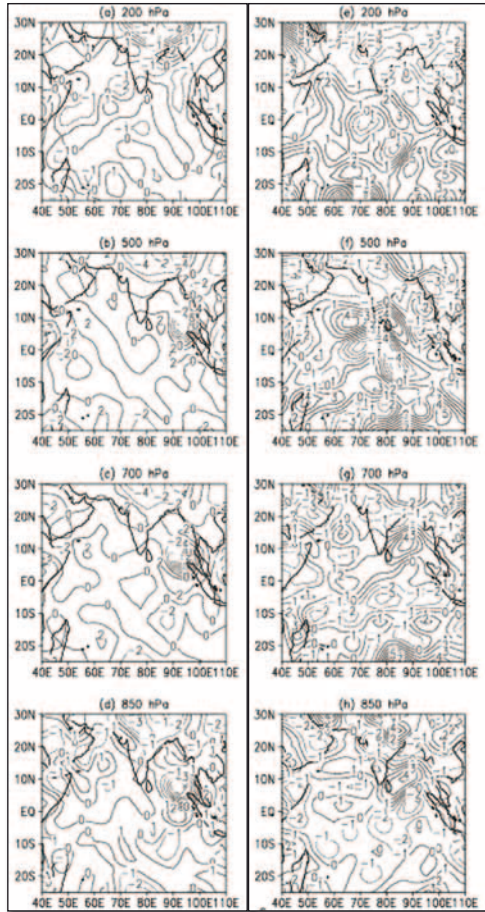


Figure 6. Same as Figure 2 except on 18 May 2009 (pre-onset).

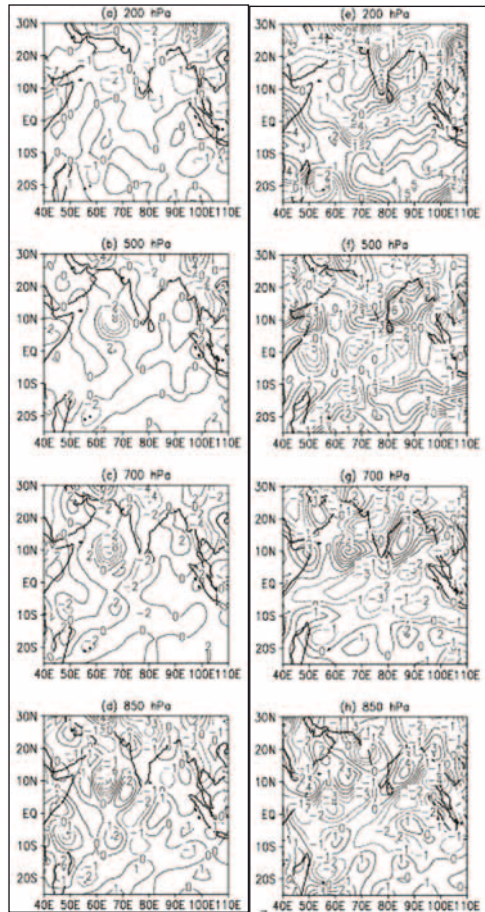


Figure 7. Same as Figure 2 except on 23 May 2009 (onset).

Similarly, southern hemispheric subtropical westerlies are seen from 15°S and are northerly in the central tropical Indian Ocean from pre-monsoon to onset periods.

Horizontal distribution of  $\zeta$  and  $\omega$  for the pre- to post-onset period for the year 2009 are presented in the Figure 6(a-h), Figure 7(a-h) and Figure 8(a-h) respectively. On the 18th May, cyclonic circulation and upward motion is evident in the central bay throughout the layer at 850-500 hPa with a maximum  $\zeta \sim 4 \times 10^{-5} \text{ s}^{-1}$  and  $\omega \sim -8 \times 10^{-3} \text{ mb s}^{-1}$  at 700 hPa (Figure 6 c and g). On the 23rd May (onset date), cyclonic circulation continued in the layer 850-500 hPa with a maximum  $\zeta \sim 6 \times 10^{-5} \text{ s}^{-1}$  (Figure 7f) at 500 hPa. Further, low-level cyclonic circulation and strong upward motion is seen in the south-central Arabian Sea (near 7°N, 65°E) with a maximum  $\zeta \sim 5 \times 10^{-5} \text{ s}^{-1}$  (Figure 7c) and  $\omega \sim -8 \times 10^{-3} \text{ mb s}^{-1}$  (Figure 7g) at 700 hPa. However, anticyclonic circulation to the north of 15°N is noticed, which is not favourable for the development of monsoons. On the 28th May, upward motion in south-central Arabian Sea continued in the layer of 850 to 500 hPa but did not move to any northward position which is comparable to the 23rd May.

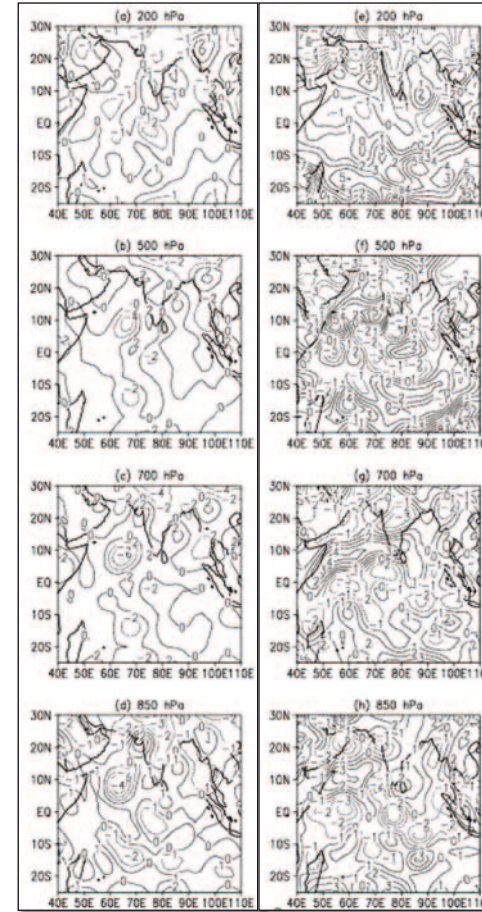


Figure 8. Same as Figure 2 except on 28 May 2009 (post-onset).

In the Bay of Bengal and the Indian land region, downward motion and anticyclonic circulation clearly indicates an unfavourable situation for the advancement of monsoon seasons (Figure 8a-h).

### Kinetic Energy

Using MONEX observations, Krishnamurti (1985) it was found that a sudden and rapid increase in the KE (Kinetic Energy) occurred just prior to the onset of monsoon regions. Many studies show that horizontal shear of the monsoon flow provides substantial energy during the evolution of the onset vortex. The onset vortex has been observed in some years though not in all, but the increases of KE is a more noticeable and common phenomenon. Therefore, KE at different vertical levels are computed. Horizontal distribution of KE at 850 hPa during the pre-onset, onset and post-onset pentad for both 2000 and 2009 are presented in the Figure 9(a-f). The zone of maximum KE in all the three pentads for the year 2000 suggests the arrival of monsoon and its steady progress. During 2009, the zone of maximum KE in the pre-onset and onset period is found to be near south-central/central Bay; due to the Aila cyclone. In addition to this, during the onset pentad, secondary maxima of KE is noticed in the south-central Arabian Sea which can be associated with the arrival of the monsoon season. However, the post-onset week shows a decrease in KE and the zone of maximum

KE lies in the equatorial Indian Ocean. Hence it is clearly indicated that only oceanic TCZ is present and the convection disappeared beyond 10°N. In fact, when KE,  $\zeta$  and  $\omega$  are computed for every day, it is found that after the arrival of the onset date of the monsoon season, only 2-3 days of convection persisted. It is worth mentioning that the computation of  $\omega$  for each day from the surface to 150 hPa from the 15th May to the 19th June indicated the unorganized large-scale circulation and each rainfall spells of 2-3 days continued only up to 14°N. To understand this phenomenon the time series of SJ and TEJ was computed.

### Time Series of Somali Jet and Tropical Easterly Jet

The time series of wind speeds at 850 hPa and 150 hPa from the 15th May to the 19th June for the years 2000 and 2009 were obtained over the SJ region (EQ-10°N, 40°E-60°E) and over TEJ region (EQ-15°N, 65°E-95°E) and are presented in the Figure 10(a-b). During 2000, it is found that there is a gradual increase in the wind speed over the SJ from 8  $\text{ms}^{-1}$  up to 17.5  $\text{ms}^{-1}$  for one pentad after the onset, whereas for the year 2009, the increase in the wind speed was from 4  $\text{ms}^{-1}$  up to 12.5  $\text{ms}^{-1}$  during the onset pentad. Thereafter, throughout the time domain, the wind speed decreased in the SJ region in 2009.

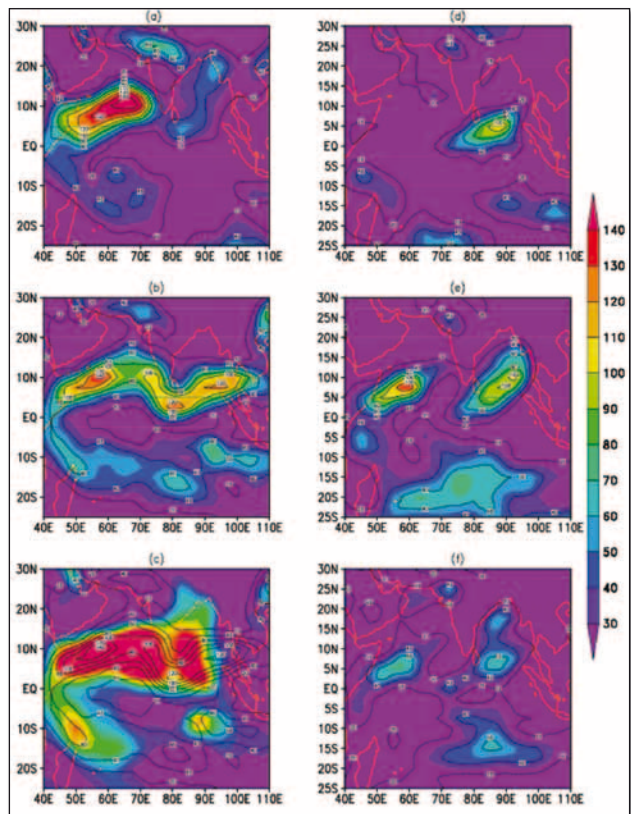


Figure 9. Horizontal distribution of Kinetic Energy ( $m^2/s^2$ ) at 850 hPa during preonset, onset and post onset pentad for the year 2000 (a-c) and 2009(d-f).

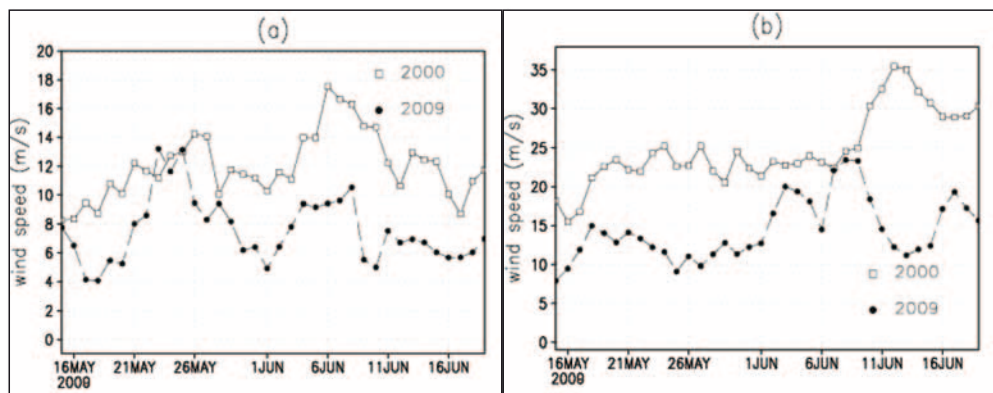


Figure 10. Time series of averaged wind speed for 2000 and 2009 - (a) Somali Jet (EQ-10N, 40E-65E) at 850 hPa and (b) Tropical Easterly Jet (EQ-15N, 65E-95E) at 150 hPa.

The wind speeds in the TEJ region are well below normal in 2009 compared to 2000. The magnitude of TEJ gradually increases from  $20 \text{ m s}^{-1}$  on the 1st June (i.e. onset) to  $35 \text{ m s}^{-1}$  on the 12th June during the year 2000. But in 2009, TEJ magnitude is only  $13 \text{ m s}^{-1}$  on the 23rd May (i.e. onset) and this reached its maximum of  $22 \text{ m s}^{-1}$  on 9 and the 10 June 2009. During the year 2000, the easterly shear between 150 hPa and 850 hPa from pre-onset to post-onset pentad is 30 to  $40 \text{ m s}^{-1}$  whereas the easterly shear for the year 2009 varies only about 16 to  $25 \text{ m s}^{-1}$  from pre-onset to post-onset pentad. In general, the weak SJ and extremely weak TEJ are not favourable to maintain meridional temperature gradients required for the development of monsoons.

## DISCUSSION AND CONCLUSIONS

During the normal onset week of the studied monsoon year of 2000, the easterly wind shear is strong enough for northward migration of TCZ. This favourable situation is continued in the post-onset week of 2000. But during the case of 2009, stronger cross-equatorial flow was temporarily established due to tropical cyclone Aila. To understand this phenomena critically, a time series of wind speed data for the three pentads of the onset phase at 850 hPa over the SJ region (EQ-10°N, 40°E-60°E) and at 150 hPa over the TEJ region (EQ-15°N, 65°E-95°E) were obtained. There is a gradual increase in the upper level easterlies from the 20th May during the onset week of 2009 with a maximum of  $14 \text{ m s}^{-1}$  on the 24th May. Thereafter, a sudden decrease in wind was noticed and again easterlies reached a maximum of only  $12 \text{ m s}^{-1}$  which is about one third of the normal value ( $36 \text{ m s}^{-1}$ ) as seen during the year 2000. The computation of vorticity, vertical velocity and KE for different vertical levels clearly indicated a weak circulation pattern throughout the troposphere in the onset and post-onset week of 2009 which would therefore be accountable and deemed to be reasonable responsibility for the delay in the monsoon progress during June 2009.

## ACKNOWLEDGEMENTS

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## TORRO TORNADO DIVISION REPORT: July 2011

By PAUL R. BROWN and G. TERENCE MEADEN

The beginning and end of July 2011 were anticyclonic, but the rest of the month had mainly cyclonic or northerly weather types. There were two tornadoes, both confirmed by site investigations, plus one in the Irish Republic (yet to be confirmed); one waterspout; 18 reports of funnel clouds, plus one in the Republic; and just one land devil.

### LD2011Jul02 Langford, Bedfordshire (52° 03' N 0° 17' W, TL 1840)

A local internet report of the village fete stated that gazebos started flying through the air at one point during the afternoon, and a tent was tipped over, apparently by a 'mini-tornado' (there was no other wind at the time). At 1200 GMT a complex area of high pressure covered the British Isles with centres of 1021 mb over East Anglia and the Irish Sea. The weather was dry with sunny periods and sea breezes round the coasts.

### FC2011Jul05 Dartmoor, near Okehampton?, Devon (c 50° 44' N 4° 01' W, SX 5895)

*Okehampton Times* of the 13th July reported that Mr Chris Goodman photographed a 'small tornado' over Dartmoor (probably near Okehampton) between 1930 and 2000 GMT the previous Tuesday. At 1800 GMT a low, 990 mb, was slow-moving to the west of Ireland, and several fronts and troughs were moving east across the British Isles. Most areas had occasional rain or showers (including Dartmoor about the time of observation).

### FC2011Jul07 Stretford, Lancashire (c 53° 27' N 2° 19' W, SJ 7994)

The *Messenger* newspaper of the 14th July published a film taken by Mr Steven Perrin of Linton Road, Sale, which appears to show a slender funnel cloud extending about a third of the way to the ground in the direction of Stretford. The time was about 1230 GMT and it lasted a few minutes from when first seen. He described it as "a long winding column of cloud snaking from underneath the cloud base."

At 1200 GMT a complex depression, main centre 992 mb, was centred near western Ireland, and troughs were rotating round it over all parts of Britain. Showers or thunderstorms occurred in most parts during the day.

### fc?2011Jul07 Lincoln, Lincolnshire (c 53° 14' N 0° 33' W, SK 9771)

Helen Rossington of TORRO drew our attention to a piece of film showing a possible funnel cloud over Lincoln (no further details known, and not counted in statistics).

### FC2011Jul08/I Weston-super-Mare, Somerset (51° 21' N 3° 00' W, ST 3162)

Mr Adrian Hockey (UKWeatherworld) witnessed a funnel cloud at about 1600 GMT which came in from the Bristol Channel and passed over Worlebury Hill before dying out. Its duration was 10-15 minutes, during which time it underwent marked variations in size and shape. His photographs show a very slender funnel reaching at least two-thirds of the way to the surface at one point. This was also reported in the *Weston, Worle & Somerset Mercury* of the 11th July, where several other people's photographs were published.

At 1200 GMT the previous day's low, now 997 mb, was centred over Ireland, and troughs continued to circulate round it over the British Isles. Further showers and thunderstorms, often in bands, affected many areas of Britain.

TN2011Jul08/I *Westhoughton, Lancashire (53° 33' N 2° 32' W, SD 648054 to SD 650059)*

The *Bolton News* of the 8th July reported that a tornado had struck the Green Meadows, Sandyway Close, and Quakerfields part of Westhoughton, near Bolton, at about 1430 GMT that day, damaging roofs, and throwing loose items into neighbouring gardens; and the BBC published a film (probably taken by Mr Lee Johnson) showing a well-developed funnel cloud reaching nearly to the ground (hidden by trees and rooftops in the distance).

Justin Parker and Tim Sharp of TORRO visited the area on the 9th and 10th, and were able to identify a damage track of 0.5 km running northnortheast from Gorsey Grove to Sandway Close on the western outskirts of the village. The maximum width (at Sandway Close) was 35 m. Witnesses spoke of a thunderstorm with torrential rain (no hail) followed by a 'whooshing' sound. They also stated that the tornado turned left after reaching Sandway Close and headed across fields to 'Dob Cross' (exact position of which is unknown), although it is impossible to verify this. Most of the damage involved the removal of roof tiles, causing some subsidiary damage as they fell; some small trees and garden fences were also affected. Force probably T1.

TN2011Jul08/II *Bognor Regis, West Sussex (50° 47' N 0° 41' W to 50° 48' N 0° 41' W, SZ 927995 to SU 934002)*

This tornado was reported in the *Brighton Argus* (8th July) soon after its occurrence at 0830 GMT, and in various other newspapers over the following days; and a full site investigation was conducted by Tony Gilbert and Neil Robbins of TORRO on the 10th. According to the *Argus*, dozens of houses suffered roof damage as the tornado was seen moving through Marshall Avenue and Highland Avenue; gardens fences and other substantial items were also carried into neighbouring gardens by the whirlwind. By the time of the site investigation much of the debris had been cleared away, but it was possible to identify a track of just under one kilometre in length and no more than five metres in width from Marshall Avenue (no. 26) northeastwards to just beyond Chichester Road (no. 58). The press report said that it then 'moved out to sea' but there is no evidence of this. Force mainly T1 but locally T2.

3FC2011Jul08/II *Whittlesey, Cambridgeshire (52° 33' N 0° 08' W, TL 2797)*

Mr Alastair Ross sent in a report of three successive funnel clouds seen at 1650 GMT, two from one storm cell, and a third larger one from another cell. Total duration was 2-3 minutes.

WS2011Jul09 *Moray Firth, near Black Isle, Ross and Cromarty (c 57° 34' N 4° 06' W, NH 7454)*

A report was received from Ms Laura K. Knowles that a funnel cloud had been seen from Invergordon across the Black Isle towards the Moray Firth during a thunderstorm between 1230 and 1330 GMT; and in a report of a golfing tournament taking place at Inverness, the *Scottish Sunday Express* (10th July) said that "Serious flooding, landslides, and even a water spout out on the Moray Firth greeted the players yesterday morning". Despite the differences of timing we are inclined to treat these as a single event. At 1200 GMT the previous day's low, now 1004 mb, was centred off the east coast of Scotland with troughs still circulating round it. Showers and thunderstorms were heavy and prolonged in eastern Scotland but much more scattered (though still locally heavy) elsewhere.

FC2011Jul10/I *Kimbolton, Cambridgeshire (52° 17' N 0° 24' W, TL 0967)*

This report was received from Ms (Mr?) Hilary Blagbrough who observed the funnel between 1230 and 1245 GMT.

It descended and retracted several times over about a 10-minute period, at one point splitting in the middle, then rejoining. There was a light shower before, and a heavier one after.

At 1200 GMT a very weak northwesterly airflow covered the British Isles between the previous day's low, now 1009 mb near south Norway, and a ridge of high pressure west of Ireland. Scattered, locally heavy, showers affected central England and Wales, while much more frequent ones affected north and east Scotland.

fc2011Jul10/II *Quadring, Lincolnshire (52° 53' N 0° 11' W, TF 2233)*

Mr Derek Williams submitted a report of 'several spinning cloud formations above the village' seen at 1800 GMT. There was a shower just after.

FC2011Jul10/III *Buntingford, Hertfordshire (c 51° 57' N 0° 01' W, TL 3629)*

Ms Kelly Moffat contacted us to say that she saw a funnel cloud from Steeple Morden which appeared to be over or near Buntingford, where a shower was falling; the time was about 1545 GMT and it lasted five minutes.

FC2011Jul19/I *Kirkby Stephen, Cumbria (c 54° 28' N 2° 21' W, NY 7708)*

An anonymous correspondent to the NetWeather internet forum published photographs of a funnel cloud seen from Kirkby Stephen in the direction of Murton Pike and Great Dun Fell (i.e. to the north). The pictures appear to show the funnel about halfway to the ground. The time of day was evening.

At 1800 GMT a weak northwesterly airstream covered England and Wales associated with a low, 998 mb, near southwest Norway, and a shower trough lay north to south over eastern counties. Showers, some of them thundery, affected central and eastern areas during the day, but elsewhere it was mostly dry.

FC2011Jul19/II *Whitchurch, Hampshire (51° 14' N 1° 21' W, SU 4648)*

This report was received second-hand via a correspondent to the UKWeatherworld forum. A film taken by a Mr Richard Long shows a somewhat shapeless overhead funnel hanging from a shower cloud (time of day not stated).

FCs/TN2011Jul20/I *Clynderwen, Pembrokeshire (c 51° 50' N 4° 44' W, SN 1219)*

Ms Natasha Oakley informed us of a 'tornado' reported on *Radio Pembrokeshire*, said to have been filmed from Narberth at about 1200 GMT, probably in the direction of Clynderwen; the film shows a long funnel cloud in the distance and at least one shorter one closer to the camera. And Ms Oakley herself saw what appeared to be 2-3 distant funnel clouds to her north or northwest (from Clynderwen) about half an hour later. The BBC showed a photograph taken by Mr Paul Woolcock from near Narberth, and the *Carmarthen Journal* of the 27th July published one taken by Mr Robert Hackett near Kilgetty; both show a large well-formed funnel reaching nearly to the ground.

At 1200 GMT a very weak northerly flow covered much of Britain, within which a low, 1006 mb, was moving southeast off southwest England and other very shallow lows were forming over eastern England. Heavy showers developed over northern England; elsewhere there was a scattering of mainly slight or moderate showers. Funnel clouds formed quite widely over England and Wales.

FC2011Jul20/II *Filton, Gloucestershire (c 51° 31' N 2° 36' W, ST 5979)*

A funnel cloud formed from a shower cloud over north Bristol (Filton) at 1630 GMT, and was seen by numerous witnesses in the area (including Mr Chris Machin, Mr Adrian Lucas, Mr Joss Kent), together with some from as far away as Bath (Mr Dom Trepess) and Portishead.

It was also reported in the *Bristol Evening Post* (21st July) and on the BBC, which published one of the best photographs of it, taken by Mr Andrew Maria, in which it appears to be two-thirds of the way to the ground (disappearing behind nearby rooftops).

FC2011Jul20/III *Beckington area, Somerset (c 51° 15' N 2° 17' W, ST 8051)*

This funnel cloud was seen by David Richards of TORRO two miles east of Frome near the Somerset/Wiltshire border, probably between 1700 and 1800 GMT.

FC2011Jul20/IV *Royal Leamington Spa, Warwickshire (c 52° 17' N 1° 33' W, SP 3165)*

This funnel cloud was widely seen and reported. The first report came from Coventry (Baginton) Airport, where it was reported as VCFC in the 1320 GMT METAR; it was also seen from Kenilworth (Mr Ashley Chrimes), Cubbington (Mr Anthony Cline), and accounts appeared in the *Coventry Telegraph* (20th July), *Birmingham Mail* (21st July), *Kenilworth Weekly News* (28th July), and *Leamington Observer* (28th July), as well as in some national newspapers, most of them containing photographs, the best of which show the funnel a good two-thirds of the way to the ground.

FC2011Jul20/V *Great Ayton, North Yorkshire (c 54° 29' N 1° 09' W, NZ 5510)*

The *Evening Gazette* (22nd July) published a photograph of a rather ill-defined slanting funnel cloud taken by Ms Vicki Allinson and Ms Nicola Moffitt at about 1030 GMT. Ms Allinson said: "We could see it spinning.... It was there for about five or six minutes".

FC2011Jul20/VI *Gibraltar Point, near Skegness, Lincolnshire (53° 05' N 0° 19' E, TF 5557)*

Mr Nick Bee reported this funnel cloud on the UKWeatherworld forum. His photographs are timed at 1500 GMT (perhaps really BST?) and show the funnel reaching at least a third of the way to the ground.

fc2011Jul21 *Glasgow (central), Lanarkshire (c 55° 51' N 4° 15' W, NS 5964)*

Jeff Blackshaw of TORRO observed what he thought was a funnel cloud to the east while travelling south out of central Glasgow by train at 1607 GMT, but he lost sight of it after about 30 seconds. (Information from Jonathan Webb of TORRO.) At 1200 GMT a northerly airstream with minor troughs covered the British Isles between a low, 996 mb, over Poland and a ridge of high pressure west of Ireland. There scattered showers, especially over central Scotland, Wales, and southern England, where some were heavy.

FC2011Jul22 *Pendle Hill, Lancashire (53° 52' N 2° 19' W, SD 7941)*

The *Lancashire Telegraph* of the 26th July published a photograph taken by Mr Danny Power of a rather short vertical funnel cloud above Pendle Hill (time not stated). The synoptic pattern was similar to that of the previous day with a weak northerly airflow and scattered showers, especially in central areas, where a few were rather heavy.

FC2011Jul *Dumfriesshire*

*BBC Scotland* published a fine photograph of a funnel cloud taken from high ground and descending well below a distant mountain summit. The photographer was Ms Morag Paterson - but unfortunately they neglected to give the essential details of time and place, other than that it was somewhere in Dumfriesshire or Galloway, probably in the last week of July.

(A photograph in the *Worcester News* of the 27th July, said to have been a funnel cloud, was probably just dense virga.)

*Whirlwinds in the Irish Republic*

FC2011Jul09 *Kilmore, County Wexford (52° 12' N 6° 33' W, S 9907)*

The Enniscorthy Echo (14th July) reported that a funnel cloud formed over Kilmore at about 1400 GMT. It referred to photographs showing 'the rotating cone of wind forming in the sky', but these were not published in the version we have seen. (See the *Moray Firth* entry above for the synoptic description.)

tn2011Jul16 *Keel, Achill Island, County Mayo (53° 59' N 10° 05' W, F 6305)*

A brief report in the *Western People* of the 20th July said that a 'mini-tornado' overturned a funfair ride and a caravan and took the roof off a portacabin; the time was 1800 GMT. According to a witness, a car was seen 'dancing on the road' and 'everything was swirling around'. At the time of writing we were awaiting the result of the site investigation. At 1800 GMT a complex depression covered the British Isles with centres of 987 and 989 mb off southeast Scotland and the north coast of Ireland respectively. An occlusion circulating round the low was returning south over western Ireland, and was close to Achill Island at this time.

*Addition to report for December 2010 (published in Int.J.Meteorology, U.K. [in press])*

FC2010Dec18 *Selsey, West Sussex (50° 44' N 0° 48' W, SZ 8593)*

An anonymous photograph was received showing a slender funnel cloud about a third of the way to the ground seen in the morning from Selsey (and probably related to the *Brighton* and *Eastbourne* events of the same day, i.e. first seen as a funnel cloud from Selsey, then as a waterspout offshore Brighton, and finally coming ashore as a tornado at Eastbourne).



## TORRO THUNDERSTORM REPORT FOR THE BRITISH ISLES: NOVEMBER - DECEMBER 2010

By BOB PRICHARD

### NOVEMBER 2010

2010 was, for the most part, an unremarkable year for thunder. Indeed, for much of the year, the weather itself was, arguably, best described as bland. This all changed in November – and thunder was by no means a bit-part player in the noteworthy closing days of the month as it accompanied some of the persistent coastal snow of that period. It was heard on six days at Ashford (County Wicklow).

Thunder was isolated until the last week of the month, but there are several reports of it. On the 2nd, it appeared amongst frequent, vigorous showers in a strong westerly airflow over northwest Ireland, western and northern Scotland, especially early in the day – when lightning destroyed telephones in several houses at Kilmelford on the Argyll coast and 15 mm diameter hailstones fell at Wishaw, Lanarkshire. Later, a lightning strike at a relay station on the Orkney island of Sanday left many locals without a telephone or broadband service for up to 36 hours. It was the second strike on the station in 17 months. On the 6th, isolated thunder occurred in showers over Ireland in the afternoon and Cardigan Bay in the evening as a small depression drifted southeastwards in a northwesterly airflow, with a further report from the Isle of Wight just after midnight. From late on the 7th into the 9th, an active frontal system moved into the country as a very deep depression sank southeastwards across Ireland and on into France. Perhaps as a result of its frontal cloud seeding lower-level convective cloud over the relatively warm seas, thundery showers developed ahead of it from the northern Irish Sea to about Ayr in the early evening of the 7th, and also drifted north to northwest just off the east coast from the Thames Estuary to the Tweed from the early hours to the early afternoon of the 8th. Behind the fronts, there was isolated coastal thunder in the east and south on the 8th/9th night, mainly over West Sussex and Hampshire.

On the 11th, another very deep depression moved east off northwest Britain, and there was isolated thunder behind its fronts amongst the blustery showers in the north and over western Ireland, whilst isolated thunder may have accompanied showers near northwestern coasts on the night of the 12th/13th. One of the month's oddities came on the 14th: a complex low pressure area covered the British Isles, and as a rain area cleared the southeast, close thunder and lightning was reported from Morden, near Wimbledon, in mid-afternoon; the thunder was also heard near Victoria Station and at Heathrow. The rain had not been particularly heavy, and this was a most unexpected event. There was also an isolated thundery shower in northeast Wales in the evening, and isolated thunder accompanied coastal showers in the south and west on the 15th and on the night of the 17th/18th.

And so to the eventful, remarkable, last week and its many incidents of thundersnow, arising from heavy convective snowfalls originating over the relatively warm seas in the very cold north to northeasterly airflow. The first, isolated, reports come from eastern and south-western coasts on the 24th and 25th. On the 26th, there was a notable thundersnow instance on Guernsey in the evening. A woman needed hospital treatment for facial burns after lightning struck her house and the telephone she was holding burst into flames. Another house was struck and the garden shed burnt down. A tree in a churchyard was split by lightning, and the church's electrical system was damaged. Jersey Airport's

radar was knocked out by lightning, disrupting flying the following morning. Penzance had large hail, then snow, and lightning struck a church at nearby Mousehole. There were a few other reports of thunder near windward coasts, especially of northeast Scotland, whilst lightning was reported seen across much of eastern Ireland, up to 40 miles inland. Isolated coastal thunder again affected the Channel Islands and the southeast coast of Ireland on the 27th. From Ashford (County Wicklow) comes a report of several cloud-to-ground strokes in mid-morning, after a few hours of intermittent thundersnow with blue lightning; there was extensive damage to telephone equipment in the area, including Dublin.

There was more coastal thunder (and much more over the open seas) amongst the snow showers on the 28th. Hailstones the size of golf balls were noted at Aberdeen, and at RAF Leuchars thunder was reported on four consecutive pre-dawn hourly observations. At nearby Auchterhouse, after a morning of occasional thunder and lightning, there was an intense lunchtime storm with lightning more than once a minute and heavy snow mixed with hail. A massive redwood tree fell on to the roof of a care home at Broughton Ferry, near Dundee, shortly after it had been struck by lightning. Four new cars worth £34,000 were damaged when lightning struck the giant sign at a Dundee motor dealership. Lightning took out Tayside Police's non-emergency phone line and badly damaged a house near Perth – two neighbouring houses were also affected. An aircraft was struck by lightning on approach to Guernsey airport in the evening; it landed safely. The 29th brought quite a few reports of thunder along the east coast from Aberdeen to north Norfolk, and near the coasts of east and southeast Ireland and Cornwall. There was a vivid and loud short-lived thundersnow storm at Louth (Lincolnshire) in mid-evening. Finally, on the 30th, there were further, isolated, reports of coastal thunder – and an inland report from near Leeds early in the day.

### DECEMBER 2010

There was much less thunder in this month of winter weather than there had been in the late November spell, as there was generally less of a convective component to the outbreaks of snow in December and the seas were colder.

The month began with isolated thunder amongst the snow showers in a northeasterly airflow near the coast of east and southeast Ireland. There was then over a fortnight without any reports until the 17th, when a northwesterly airflow gave wintry showers and isolated thunder to parts of northwest Wales and the far southwest of England. On the 18th, thunder affected various coastal districts, especially around the eastern English Channel during the middle of the day in a band of snow from the west that caused havoc to aircraft operations at airports in southeast England. Thunder, large hail and a possible tornado were reported from Eastbourne. At the other end of the country, there was a two-hour power cut in parts of Shetland following a lightning strike. There also may have been thunder in a few northeastern coastal regions in an easterly airflow on the 19th.

The 20th was a day of complex low pressure in the vicinity of the English Channel, and thunder appeared in a few localities amongst the outbreaks of rain and snow – especially in south Devon and the Channel Islands. Lightning struck the Grand Hotel, Torquay, damaging telecommunications. The 21st brought isolated thunder near eastern and southern coasts, and thunder may also have affected parts of the coast of northeast England on the 22nd. Finally, for 2010, thunder was reported from the Dublin area on the 23rd.

2010 was an unusual year for thunderstorm statistics: it was widely the quietest year for thunder on record (for over fifty years) in southern England, but the frequency of thunder was much above normal over much of eastern Scotland.

## WEATHER STATION READINGS IN BERGENFIELD NEW JERSEY, NEW YORK, USA: MARCH AND APRIL 2011

### MARCH 2011

March saw temperatures that averaged exactly normal...41.8 °F (10.8 °C). However, there was considerable variation during the month. I recorded a low of 18 °F (-7.8 °C) on the 3rd. A quick warm-up ensued and on the 18th a summer-like 78 °F (25.6 °C) was reached. This set a new record for the date. Colder conditions arrived after a few days and the remainder of the month saw temperatures averaging a few degrees below normal.

Precipitation was heavy and totaled 6.81" (173.0 mm). This was about 150 % of what we would normally expect for the month.

| DAY | TEMPERATURE |      |      | PRECIPITATION |      | WIND SC | GUST | TEMPERATURE |      |      | PRECIP |      |
|-----|-------------|------|------|---------------|------|---------|------|-------------|------|------|--------|------|
|     | MAX         | MIN  | AVG  | RAIN          | SNOW |         |      | DIR         | MAX  | MIN  | AVG    | RAIN |
| 1   | 48          | 30   | 39   |               |      | 26      | N    | 8.9         | -1.1 | 3.9  |        |      |
| 2   | 54          | 24   | 39   |               |      | 37      | N    | 12.2        | -4.4 | 3.9  |        |      |
| 3   | 35          | 18   | 27   |               |      | 24      | N    | 1.7         | -7.8 | -3.1 |        |      |
| 4   | 43          | 21   | 32   |               |      | 22      | ESE  | 6.1         | -6.1 | 0.0  |        |      |
| 5   | 63          | 38   | 51   |               |      | 28      | SE   | 17.2        | 3.3  | 10.3 |        |      |
| 6   | 55          | 51   | 53   | 2.54          |      | 28      | SE   | 12.8        | 10.6 | 11.7 | 64.5   |      |
| 7   | 53          | 32   | 43   | 0.11          |      | 28      | N    | 11.7        | 0.0  | 5.8  | 2.8    |      |
| 8   | 48          | 27   | 38   |               |      | 13      | N    | 8.9         | -2.8 | 3.1  |        |      |
| 9   | 43          | 28   | 36   |               |      | 25      | E    | 6.1         | -2.2 | 1.9  |        |      |
| 10  | 54          | 36   | 45   | 1.73          |      | 31      | E    | 12.2        | 2.2  | 7.2  | 43.9   |      |
| 11  | 57          | 40   | 49   | 1.02          |      | 42      | SW   | 13.9        | 4.4  | 9.2  | 25.9   |      |
| 12  | 57          | 37   | 47   |               |      | 24      | SW   | 13.9        | 2.8  | 8.3  |        |      |
| 13  | 51          | 39   | 45   |               |      | 26      | W    | 10.6        | 3.9  | 7.2  |        |      |
| 14  | 45          | 30   | 38   |               |      | 16      | N    | 7.2         | -1.1 | 3.1  |        |      |
| 15  | 50          | 25   | 38   |               |      | 17      | ESE  | 10.0        | -3.9 | 3.1  |        |      |
| 16  | 59          | 37   | 48   | 0.44          |      | 13      | W    | 15.0        | 2.8  | 8.9  | 11.2   |      |
| 17  | 68          | 41   | 55   |               |      | 18      | S    | 20.0        | 5.0  | 12.5 |        |      |
| 18  | 78          | 49   | 64   |               |      | 27      | N    | 25.6        | 9.4  | 17.5 |        |      |
| 19  | 60          | 37   | 49   |               |      | 27      | NW   | 15.6        | 2.8  | 9.2  |        |      |
| 20  | 54          | 31   | 43   |               |      | 14      | N    | 12.2        | -0.6 | 5.8  |        |      |
| 21  | 43          | 33   | 38   | 0.44          | 0.3  | 16      | SE   | 6.1         | 0.6  | 3.3  | 11.2   | 0.8  |
| 22  | 52          | 37   | 45   |               |      | 19      | WNW  | 11.1        | 2.8  | 6.9  |        |      |
| 23  | 42          | 33   | 38   | 0.27          | 0.2  | 14      | NE   | 5.6         | 0.6  | 3.1  | 6.9    | 0.5  |
| 24  | 46          | 29   | 38   | 0.19          | 1.4  | 19      | N    | 7.8         | -1.7 | 3.1  | 4.8    | 3.6  |
| 25  | 44          | 27   | 36   |               |      | 21      | W    | 6.7         | -2.8 | 1.9  |        |      |
| 26  | 43          | 24   | 34   |               |      | 22      | W    | 6.1         | -4.4 | 0.8  |        |      |
| 27  | 46          | 26   | 36   |               |      | 22      | W    | 7.8         | -3.3 | 2.2  |        |      |
| 28  | 49          | 25   | 37   |               |      | 24      | WNW  | 9.4         | -3.9 | 2.8  |        |      |
| 29  | 51          | 29   | 40   |               |      | 26      | W    | 10.6        | -1.7 | 4.4  |        |      |
| 30  | 58          | 29   | 44   |               |      | 18      | S    | 14.4        | -1.7 | 6.4  |        |      |
| 31  | 43          | 37   | 40   | 0.07          |      | 16      | NE   | 6.1         | 2.8  | 4.4  | 1.8    |      |
| AVG | 51.4        | 32.3 | 41.8 |               |      |         |      | 10.8        | 0.1  | 5.4  |        |      |
| SUM |             |      |      | 6.81          | 1.9  |         |      |             |      |      | 173.0  | 4.8  |
| MAX | 78          | 51   | 63.5 | 2.54          | 1.4  | 42      | sw   | 25.6        | 10.6 | 17.5 | 64.5   | 3.6  |
| MIN | 35          | 18   | 27   |               |      |         |      | 1.7         | -7.8 | -3.1 |        |      |

*Weather station data for Bergenfield, New Jersey, USA - March 2011.  
Note, peak gusts are shown in mph. \*SC = Snow Cover.*

A new daily record was recorded on the 6th when 2.54" (64.5 mm) fell. A few days later, on the 10th and 11th, considerable rainfall throughout the region led to serious flooding along the Pascack River. Towns along its lower reaches suffered from widespread property damage. After a snowy winter, March brought little snowfall. I measured a total of 1.9" (4.8 cm). This brings the season's total up to 59.2" (150.4 cm)...about twice the long-term mean.

| DAY | TEMPERATURE |      |      | PRECIPITATION |      | WIND SC | GUST | TEMPERATURE DIR | MAX  | MIN  | AVG   | PRECIP |      |
|-----|-------------|------|------|---------------|------|---------|------|-----------------|------|------|-------|--------|------|
|     | MAX         | MIN  | AVG  | RAIN          | SNOW |         |      |                 |      |      |       | RAIN   | SNOW |
| 1   | 43          | 35   | 39   | 0.18          | T    | 24      | N    | 6.1             | 1.7  | 3.9  | 4.6   | T      |      |
| 2   | 57          | 37   | 47   |               |      | 31      | W    | 13.9            | 2.8  | 8.3  |       |        |      |
| 3   | 60          | 41   | 51   |               |      | 27      | W    | 15.6            | 5.0  | 10.3 |       |        |      |
| 4   | 63          | 43   | 53   | 0.10          |      | 19      | ESE  | 17.2            | 6.1  | 11.7 | 2.5   |        |      |
| 5   | 66          | 41   | 54   | 0.15          |      | 32      | W    | 18.9            | 5.0  | 11.9 | 3.8   |        |      |
| 6   | 57          | 35   | 46   | 0.08          |      | 27      | SW   | 13.9            | 1.7  | 7.8  | 2.0   |        |      |
| 7   | 51          | 39   | 45   | 0.07          |      | 10      | NNE  | 10.6            | 3.9  | 7.2  | 1.8   |        |      |
| 8   | 50          | 36   | 43   |               |      | 12      | ESE  | 10.0            | 2.2  | 6.1  |       |        |      |
| 9   | 63          | 34   | 49   |               |      | 16      | SE   | 17.2            | 1.1  | 9.2  |       |        |      |
| 10  | 58          | 40   | 49   |               |      | 13      | SE   | 14.4            | 4.4  | 9.4  |       |        |      |
| 11  | 87          | 51   | 69   |               |      | 20      | S    | 30.6            | 10.6 | 20.6 |       |        |      |
| 12  | 73          | 48   | 61   | 0.88          |      | 24      | N    | 22.8            | 8.9  | 15.8 | 22.4  |        |      |
| 13  | 50          | 44   | 47   | 0.61          |      | 29      | NE   | 10.0            | 6.7  | 8.3  | 15.5  |        |      |
| 14  | 73          | 44   | 59   |               |      | 17      | NW   | 22.8            | 6.7  | 14.7 |       |        |      |
| 15  | 59          | 41   | 50   |               |      | 19      | E    | 15.0            | 5.0  | 10.0 |       |        |      |
| 16  | 55          | 39   | 47   | 2.28          |      | 33      | E    | 12.8            | 3.9  | 8.3  | 57.9  |        |      |
| 17  | 61          | 47   | 54   | 0.74          |      | 32      | WSW  | 16.1            | 8.3  | 12.2 | 18.8  |        |      |
| 18  | 63          | 40   | 52   |               |      | 20      | SE   | 17.2            | 4.4  | 10.8 |       |        |      |
| 19  | 50          | 44   | 47   | 0.06          |      | 19      | N    | 10.0            | 6.7  | 8.3  | 1.5   |        |      |
| 20  | 69          | 44   | 57   |               |      | 17      | E    | 20.6            | 6.7  | 13.6 |       |        |      |
| 21  | 60          | 41   | 51   |               |      | 32      | W    | 15.6            | 5.0  | 10.3 |       |        |      |
| 22  | 52          | 32   | 42   |               |      | 16      | ESE  | 11.1            | 0.0  | 5.6  |       |        |      |
| 23  | 58          | 43   | 51   | 0.93          |      | 18      | ESE  | 14.4            | 6.1  | 10.3 | 23.6  |        |      |
| 24  | 83          | 53   | 68   | 0.08          |      | 19      | SW   | 28.3            | 11.7 | 20.0 | 2.0   |        |      |
| 25  | 77          | 57   | 67   |               |      | 16      | ESE  | 25.0            | 13.9 | 19.4 |       |        |      |
| 26  | 85          | 55   | 70   |               |      | 24      | SE   | 29.4            | 12.8 | 21.1 |       |        |      |
| 27  | 78          | 63   | 71   |               |      | 19      | ESE  | 25.6            | 17.2 | 21.4 |       |        |      |
| 28  | 77          | 62   | 70   | 0.72          |      | 29      | SE   | 25.0            | 16.7 | 20.8 | 18.3  |        |      |
| 29  | 71          | 49   | 60   |               |      | 22      | WSW  | 21.7            | 9.4  | 15.6 |       |        |      |
| 30  | 70          | 49   | 60   |               |      | 17      | N    | 21.1            | 9.4  | 15.3 |       |        |      |
| 31  |             |      |      |               |      |         |      |                 |      |      |       |        |      |
| AVG | 64.0        | 44.2 | 54.1 |               |      |         |      | 17.8            | 6.8  | 12.3 |       |        |      |
| SUM |             |      |      | 6.88          | T    |         |      |                 |      |      | 174.8 | T      |      |
| MAX | 87          | 63   | 70.5 | 2.28          | T    | 33      | E    | 30.6            | 17.2 | 21.4 | 57.9  | T      |      |
| MIN | 43          | 32   | 39   |               |      |         |      | 6.1             | 0.0  | 3.9  |       |        |      |

*Weather station data for Bergenfield, New Jersey, USA - April 2011.  
Note, peak gusts are shown in mph.  
\*SC = Snow Cover.*

### APRIL 2011

April temperatures averaged 54.1°F (12.3 °C). This is 1.7 °F (0.9 °C) above the long term mean. Other than during a brief warm-up on the 11th when the temperature soared to 87 °F (30.6 °C), the month's high, temperatures were below average during the first three weeks of the month. However, temperatures rose to June-like levels during the final week.

What was probably the last frost of the season occurred on the 22nd when the month's low of 32 °F (0.0 °C) was recorded. Interestingly, the month's high and low temperature each set a daily record. April was the second consecutive with well above normal precipitation. I measured 6.88" (174.8 mm). Snow fell briefly during the morning of the 1st.



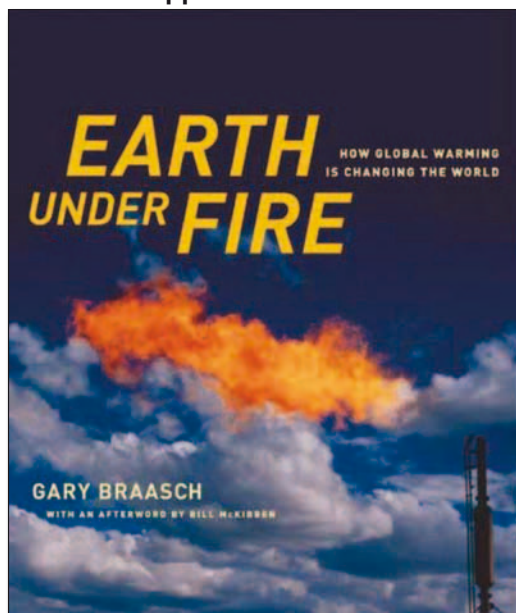
## BOOK REVIEWS

By PETER ROGERS

**EARTH UNDER FIRE: HOW GLOBAL WARMING IS CHANGING THE WORLD**  
 BY Gary Braasch ( with an Afterword by Bill McKibben) ISBN:978-0-520-24438-2. (2007) University of California Press hb pp267

There is no doubt that climate change has produced a spate of books on the subject – inevitably of variable quality, but this one certainly stands out if only because of the quality of the colour photographs. These were all taken by Gary Braasch, an Ansel Adams Award-winning photographer, and prolific contributor to publications such as Smithsonian, Scientific American, Time, US News and World Report.

The five chapters are respectively entitled, 'Fire on Ice'; 'Polar Thaw'; 'Breaking the Boundaries of Life'; 'Tomorrow's Climate Today'; and 'Choosing a Safer, Cleaner and Cooler World' Each chapter is of course dominated by Ansel Adams's stunning and thought-provoking photographs. However, there is at least one, and in one case three, accompanying essays which fulfil the chapter's title. The final chapter, running to over 50 pages is an extended essay with some photographs. The Epilogue consists of two pages, while Bill McKibben's "Afterword" ends with the following paragraph:



*"One of the key questions – a question that will go a long way toward determining just how hot the planet gets – is whether China and India will take Europe as an example, or look to America. The sooner they start to deflect their trajectories away from ours, the better, because with each passing year the options narrow, the math get harder. How many hurricanes will it take, exactly, for the message to start getting through?"*

This was written two years ago, but at least there are signs of change from the new US Administration, and it must be hoped that the Stockholm Conference, to be held in December, will make real progress towards curbing global emissions – all over the world. Delegates could do much worse than read this important book. It may look like a glossy coffee-table offering, but it is much more than that.

**AND NOW THE SHIPPING FORECAST** by Peter Jefferson ISBN 978:-1-906860-15-8. (2011) UIT Cambridge Ltd. pb. pp 256, £10.99.

For over 40 years, the author of this delightful book, Peter Jefferson, as part of his duties as a BBC continuity announcer, presented The Shipping Forecast and he tells us all that there is to know about this BBC institution.

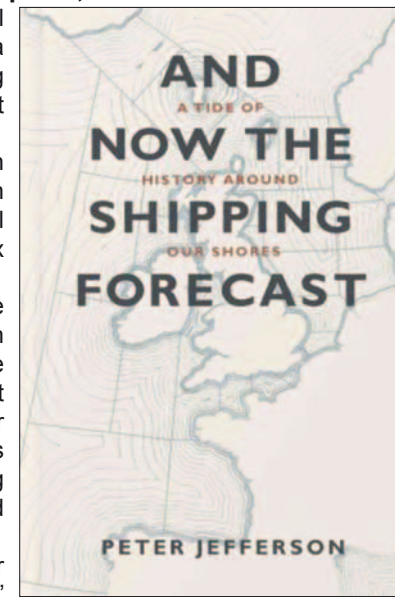
His book is divided into fifteen chapters, in addition to which there is a 2 page Glossary, which helpfully defines the numerous meteorological acronyms; a Sources and Further Reading appendix that runs to 14 pages and a fifteen page Index.

The first few chapters tell the history of the Shipping Forecast, and the following three explain how the development of technology has changed the way the forecast is prepared, but we are reminded that it is always 300 words in length, and the announcer has precisely three minutes to present it. Two chapters are devoted to a description of each of the existing forecast areas, and why some of them have changed their names.

After an exegesis on Lighthouses, Chapter 12 is entitled 'Codes Conventions and Traditions' which include 16 pages, each of which describes the history of well-known expressions, ranging from "As the Crow Flies" to "Splicing the Mainbrace". A whole chapter is devoted to the programme's "signature tune" 'Sailing By', and its composer, Ronald Binge.

There are a few black and white photographs, including a portrait of Admiral Beaufort, and one of the "new" Met Office building in Exeter. The book is written in an easy conversational style and is full of delightful stories. Too long to reproduce in this review is the "spoof" broadcast that was never transmitted, that has left your reviewer, and everybody to whom he has shown or read it reduced to tears of laughter (pp 21/2).

The price is extremely reasonable, and I recommend every reader of this Journal to buy at least one copy- the other can be given to a friend or acquaintance who, I feel sure will enjoy it just as much as those with a particular interest in meteorology in general and the Shipping Forecast in particular.


**HOW TO COPE WITH STORMS (2nd Edition)** by D von Haefen ISBN: 978-1-4081-3291-3 (2011) Adlard Coles Nautical pb pp176 £14.99

This is the second edition of a book first published in English in 1997, and obviously designed with sailors in mind, as are most of the excellent Adlard Coles books. Of the 19 chapters, the first seven deal with meteorological phenomena, particularly with wind, while most of the other chapters contain practical advice such as "The Crew", "Manoeuvres in Harbour", and "Emergencies". The "weather" chapters are clearly written and well illustrated with maps, weather charts, diagrams and tables and give a good introduction of the topic for inshore yachtsmen. Your reviewer is not qualified to judge the rest of the book, though it seems to be written and illustrated in the same clear and helpful way. The price is very competitive and the book would easily fit into the pocket of a sou'wester.

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