WeatherNet Limited | Kingsland House | 21 Hinton Road | Bournemouth | BH1 2DE | Phone +44 1202 296396

15th April 2019

XXXXX XXXXX
XXX
XXXXXX
XXXXXXXX
XX XXXXXX
XXXXXX
XXXXXXXX XX XXX

Dear XXXXX,

Incident

Location: Thyrbergh Bar Mill, Aldwarke, Rotherham (S65 3SR)
Date: 13th December 2015
Time: 05:45 GMT
Your Reference: XXXX.XXXX

Please find enclosed a legal meteorological report requested for this incident. The purpose of this meteorological report was to give an expert opinion based on the meteorological facts as to the most likely meteorological conditions in the above area on the date and time indicated. The meteorological issues addressed included examining meteorological data from professional meteorological stations, synoptic meteorological charts, lightning maps, amateur meteorological stations, witness statements, remote sensed data and radar imagery. This meteorological report complies with civil and criminal procedures. This meteorological report based on meteorological data and opinion therefore should prove quite representative of the area of the incident.

I very much hope that the information is acceptable and please do not hesitate to call if you are in need of further assistance in this or in any other legal case in the future.

Yours sincerely

Dr Richard Wild BSc (Hons) PhD FRMetS FRGS MAE MCSFS
Chief Meteorologist
Direct: 01202 293867
Mobile: 07967 561549
E-mail: rick@weathernet.co.uk

Encl.: Weather report with respect to the legal case at Thyrbergh Bar Mill, Aldwarke, Rotherham (S65 3SR) on 13th December 2015

Legal Meteorological Report

Your Reference: XXXX XXXX
Location Date: 15th April 20
Incident: XXX XXXXXXXXX

Prepared for and instructed by

XXXXX XXXXX
XXX
XXXXXX
XXXXXXXX
XX XXXXXX
XXXXXX
XXXXXXXX XX XXX
Telephone: XXXX XXX XXXX
Direct Telephone: XXXX XXX XXXX
Email: XXXXX.XXXXX@XXXXXX.XXX

Author

Dr Richard J. Wild | Chief Meteorologist | WeatherNet Ltd
Telephone: 01202 293867 | Mobile: 07967 561549 | Email: rick@weathernet.co.uk

Kingsland House, 21 Hinton Road, Bournemouth, BH1 2DE

Meteorological report for postcode S65 3SR for the 13th December 2015

Contents

1. Introduction

1.1 The writer

I am Dr Richard John Wild, Chief Meteorologist at WeatherNet Ltd. My specialist field is in forensic meteorology. My qualifications include a BSc (Hons) in Geography (2:1) (obtained June 1994) and a PhD investigating the spatial and temporal analysis of heavy snowfalls across Great Britain between the years 1861-1999 (obtained July 2005). WeatherNet Ltd is a private weather consultant and is solely responsible for the conclusions and opinion expressed in this report. WeatherNet Ltd is an Authorised Data user by agreement with the Met Office, Exeter and its own private meteorological network across the United Kingdom. The meteorological data from the Met Office abides by the standards set by the World Meteorological Organisation, based in Geneva as the instruments at these meteorological stations, as well as the stations themselves are constantly checked for reliability.

1.2 Summary background of the case

I have been asked to provide a detailed meteorological report, giving an expert opinion based on the meteorological factors to the probable meteorological conditions in the above area on the date and time indicated. This meteorological report complies with civil and criminal procedure and the Jackson reforms. As far as I am aware, I have no connection with any of the parties involved in the incident.

1.3 Report prepared XX

1.4 Your reference XXX/XX/XX

1.5 Place of incident Tinsbergh Bank, Aldwarke, Rotherham (S65 3SR)

1.6 Date of incident 13th December 2015

1.7 Time of incident 05:45 GMT

1.8 Summary and conclusions

With these factors in mind, I conclude, based on my opinion, meteorological facts and data stated in this report, that on the balance of probability that the best-estimate that during the incident period, gentle variable/north to north-easterly winds with gusts ~5mph occurred. Air temperatures were ~1-2°C, while the weather was dry with generally cloudy skies. Remnants of precipitation amounts from the previous day on the ground surface and associated ground frost that occurred that morning due to ground temperatures at or slightly below freezing point would have resulted in some icy patches/glaze to form if untreated by anti-winter measures. At the time of the incident, ground temperatures would have been at slightly below freezing point, based on air temperatures of ~1-2°C, so some icy patches due to the ground frost etc. would still be possible on the ground surface.

Please note, however, several different factors that can also play a part in determining whether ice will form on a road/ground surface. These can include the levels of traffic at the time of the incident and throughout the day/night (heat will be added to the road surface via sensible and latent heat (see section 7.16 for definition) and moisture fluxes from the engine and exhaust, as well as additional heat dissipation from the tyres and braking). Traffic can also prevent the lessen radiating heat loss from the road/ground surface to the night sky, again preventing or limiting the formation of ice/frost. Road/ground surface temperatures generally respond quickly to changes in weather conditions, particularly the change from clear to cloudy conditions or the reserve of this; however, many factors may determine this. The movement of traffic however will cause additional mixing of air above the road/ground surface promoting increased turbulent flow, which in turn may prevent or limit the formation of frost and ice from forming, whether the road/ground surface is sheltered by surrounding buildings, hedgerows or underpasses that could stop direct sunlight or winds affecting the road/ground surface, the thermal conductivity/diffusivity of the road/ground surface (road/ground surfaces tend to retain more heat than surrounding surfaces and hence, ground frost or ice usually takes a longer amount of time to form on a road in comparison to grass), the presence of rock salt/sodium chloride, etc. and finally the interaction of geographical/topography surrounding the road is a major factor causing the difference in air temperature and road/ground surface temperature across a traffic network. It is out of my field of expertise to comment on gritting and how it affects ice/snow and on individual/council interventions.

1.9 The parties involved

I have prepared this meteorological report for and on behalf of XXX.

1.10 Technical terms and explanations

If any technical terms are used within this meteorological report, then the explanatory notes section should be consulted in the appendices for further details.

2. The meteorological issues addressed and a statement of instructions

I have prepared this meteorological report for and on behalf of XXX, contained in correspondence and instructions dated the 28th March 2019. The purpose of this meteorological report is to give an expert opinion based on the meteorological conditions as to the probable meteorological conditions in the above area on the date and time indicated. The meteorological issues addressed (if available) involved examining meteorological data from professional ground based meteorological stations, synoptic meteorological charts, lightning maps, amateur meteorological stations, remote sensed data and rainfall radar imagery. This meteorological report complies with civil and criminal procedures and the Jackson reforms. This meteorological report has been produced without the benefit of a site visit or investigation to clarify some of the opinions expressed; however, I have familiarised myself with the incident site through other information made available to

me. This meteorological report has been prepared with the full recognition that it may be presented in court as evidence. It is also accepted that this report may be submitted by another expert to the court, separate to or form part of a report.

3. Details of ground based meteorological/rainfall stations, Remote Sensed data (UKPP) and Rainfall Radar utilised

To establish what meteorological conditions occurred around the surrounding area at the time of the incident, I investigated which were the closest hourly meteorological stations, UKPP, Rainfall Radar, daily meteorological stations and daily rainfall stations.

The closest meteorological and rainfall stations to the incident were as follows:
The nearest hourly stations to the incident are Sheffield, Finningley Moor and Nottingham.
The nearest daily stations to the incident are Sheffield, Ryhill, Finningley Moor No. 2, Gringley-on-the Hill, Middleton Hillside, Scamham, Normanby Hall, Nottingham (Watnall).
The nearest daily rainfall stations to the incident are Rotherham, Templebrook.
These hourly and daily meteorological/rainfall data (manned and automatic weather stations) should prove to be representative of the incident area.

To establish, what weather conditions occurred across the incident postcode area itself at the time of the incident, I also investigated UKPP and Rainfall Radar data. UKPP data however was not available for the incident date.

4. My opinion, interpretation and conclusion

In addition to the hourly and daily meteorological data presented in the appendices within this meteorological report, I have also examined (but not included) other meteorological data based from other meteorological sources, for examp examining synoptic meteorological charts, lightning maps and amateu meteorological stations (where available for the incident date). Bas upon data analysis, a study of the general meteorological situation and asp of meteorological theory, my conclusions, interpretation, interpolation opin therefore are as follows based on the relevant data available to me wi given time frame to produce this report.

The 13th December 2015 at 00:00 saw low pressure ated across northern Iceland, the Azores and across North Africa. High pres was located to the north of Northern Ireland, northern Italy and acros d North Atlantic Ocea n occluded front affected southern areas of les, c al Eng and E t Anglia. A warm front affected South Wales, w a cold fron ffected s and SE England.

The 13th December 2015 acr the S65 ostcode area at 05:45 saw light and variable/north to north-eas inds (B fort Scale 1). The highest gusts that occurred within the incident are du that mo g period were ~5mph. Other meteorological factors occurring er t ncident e included, air temperatures were ~1-2°C, hum y values wer =95 hile the weather was dry with generally cloudy r to the ident, e light to moderate rain/showers had fallen across th ciden a th revious day and concluded ~20:30 producing ~14mm of p itation easurable precipitation then occurred across the incident area b en 21:00 on the 12th and the time of the incident on the 13 ecipitation th ccurred on the 12th would have produced a wet surface ith sta water (pu les) to be present. From late evening onwards on the 12th, temp ur ped, resulting in ground temperatures to approach and then slightly below freezing point ~02:00 resulting in a ground frost to develop. A mperatures however remained above freezing point at all times. With ground temp atures at or slightly below freezing point, this would have also r in ar mnants of this precipitation from the previous day to result in some icy pat s/gla e to form on the ground surface from early morning if untreated by anti-wint measures. At the time of the incident, ground temperatures would have been at ghtly below freezing point, based on air temperatures of ~1-2°C, so some icy p les due to the ground frost etc. would still be possible on the ground surface if untreated.

These meteorological readings presented above are based on real meteorological data recorded at nearby weather stations and 'synthetic observations'. Synthetic observations are as accurately mapped as possible based on the postcode of the incident via modelled data which is produced from the Met Office. Synthetic

observations are determined by using local observations with a wide range of inputs, including satellite, radar, buoy and weather balloon data. This information is then fed into the Met Office supercomputer, which uses a new custom-designed model to map out the weather across the whole of the UK. It intelligently fills in gaps to create 'synthetic observations' for the entire country down to a 2km grid. The system even considers local geography, such as altitude and exposure, to make the most accurate assessment of the weather for every postcode across the UK. The 'synthetic observations' viewed shows a close resemblance to actual recorded figures from nearby weather stations to the incident.

With these factors in mind, I conclude, based on my opinion, meteorological facts and data stated in this report, that on the balance of probability that the best-informed estimate that during the incident period, gentle variable/north to north-easterly winds with gusts ~5mph occurred. Air temperatures were ~1-2°C, while the weather was dry with generally cloudy skies. Remnants of precipitation accounts from the previous day on the ground surface and associated ground frost that occurred that morning due to ground temperatures at or slightly below freezing point would have resulted in some icy patches/glaze to form if untreated by anti-winter measures. At the time of the incident, ground temperatures would have been at slightly below freezing point based on air temperatures of ~1-2°C, so some icy patches due to the ground frost formation would still be possible on the ground surface.

Please note, however, several different factors that can also play a part in determining where will form on the road/ground surface. These can include the levels of traffic at the time of the incident and throughout the day/night (heat will be added to the road surface via sensible and latent heat (see section 7.16 for definition) and moisture fluxes from the engine and exhaust, as well as frictional heat generation from the tyres and braking). Traffic can also prevent/lessen radiative heat loss from the road/ground surface to the night sky, again preventing or limiting the formation of ice/frost. Road/ground surface temperatures generally respond quickly to changes in weather conditions, particularly the change from clear to cloudy conditions or the reserve of this; however, many factors may determine this. The movement of traffic however will cause additional mixing of air above the road/ground surface promoting increased turbulent flow, which in turn will however limit the formation of frost and ice from forming, whether the road/ground surface is sheltered by surrounding buildings, hedgerows or underpasses that could stop direct sunlight or winds affecting the road/ground surface, the thermal conductivity/diffusivity of the road/ground surface (road/ground surfaces tend to retain more heat than surrounding surfaces and hence, ground frost or ice usually takes a longer amount of time to form on a road in comparison to grass), the presence of rock salt/sodium chloride, etc. and finally the interaction of geographical/topography surrounding the road is a major factor causing the difference in air temperature and road/ground surface temperature across a traffic network. It is out of my field of expertise to comment on gritting and how it affects ice/snow and on individual/council winter plans.

5. Expert's declaration

I **Dr Richard J. Wild** declare that:

1. I understand that my duty in providing written meteorological reports and giving evidence is to help the Court, and that this duty overrides any obligation to XXX by whom I am engaged or the person who has paid or is liable to pay me. I confirm that I have complied and will continue to comply with my duty.
2. I confirm that I have not entered into any arrangement where the amount or payment of my fees is in any way dependent on the outcome of the case.
3. I know of no conflict of interest of any kind, other than any which I have disclosed in my meteorological report.
4. I do not consider that any interest which I have disclosed affects my suitability as an expert witness on any issues on which I have given evidence.
5. I will advise XXX by whom I am instructed if, between the date of my meteorological report and the trial, there is a change in circumstances which affect my answers to points 3 and 4 above.
6. I have shown the sources of all information I have used.
7. I have exercised reasonable care and skill in order to be accurate and complete in preparing this meteorological report.
8. I have endeavoured to include in my meteorological report those matters, of which I have knowledge or to which I have been made aware, that might adversely affect the validity of my opinion. I have clearly stated any qualifications to my opinion.
9. I have not, in forming an independent view, included or excluded anything which has been suggested to me by others, including my instructing lawyers XXX.
10. I will notify XXX immediately and confirm in writing if, for any reason, my meteorological report requires correction or qualification.
11. I understand that:
    - 11.1 my meteorological report will form the evidence to be given under oath or affirmation;
    - 11.2 questions may be put to me in writing for the purposes of clarifying my meteorological report and that my answers shall be treated as part of my meteorological report and covered by my statement of truth;
    - the court may at any stage direct a discussion to take place between experts for the purpose of identifying and discussing the expert issues in the proceedings, where possible reaching an agreed opinion on those issues and identifying what action, if any, may be taken to resolve any of the outstanding issues between the parties;
    - 11.4 the court may direct that following a discussion between the experts that a statement should be prepared showing those issues which are agreed, and those issues which are not agreed, together with a summary of the reasons for disagreeing;
    - 11.5 I may be required to attend court to be cross-examined on my meteorological report by a cross-examiner assisted by an expert;

11.6 I am likely to be the subject of public adverse criticism by the judge if the Court concludes that I have not taken reasonable care in trying to meet the standards set out above.

12. I have read Part 35 of the Civil Procedure Rules, the accompanying practice direction and the Guidance for the instruction of experts in civil claims and I have complied with their requirements.
13. I am aware of the practice direction on pre-action conduct. I have acted in accordance with the Code of Practice for Experts.

6. Statement of truth

I confirm that I have made clear which facts and matters referred to in this meteorological report are within my own knowledge and which are not. Those which are within my own knowledge I confirm to be true. The opinions I have expressed represent my true and complete professional opinions on the matters to which they refer.

7. Date and signature

Date: 15th April 2019

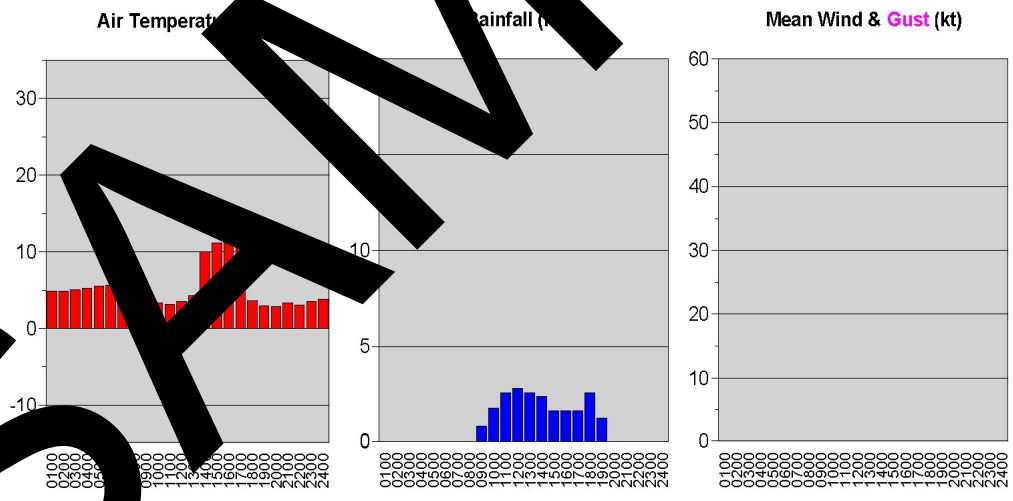
To: XXXXX XXXXX
XXX
XXXXXX XXXXXXXX
XX XXXXXX XXXXXX
XXXXXX XX

Signed:

Richard J. Child BSc (Hons) PhD FRMetS FRGS MAE MCSFS
Chief Meteorologist, WeatherNet Ltd

Weather at Sheffield (131m ASL) 8.2 miles SW of S65 3SR (20m ASL)
Saturday 12 December 2015

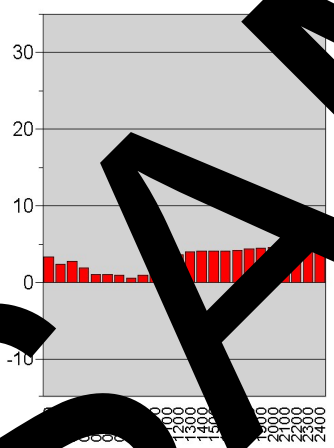
GMT	Air Temp	Humidity	Rain	Visibility	Sun	Cloud Cover	Wind From	Mean Wind	Max Gust	Weather
0100	4.9°C	82.7%	0.0mm		0hr					No data
0200	4.9°C	82.1%	0.0mm		0hr					No data
0300	5.1°C	80.4%	0.0mm		0hr					No data
0400	5.3°C	78.7%	0.0mm		0hr					No data
0500	5.5°C	77%	0.0mm		0hr					No data
0600	5.6°C	74.9%	0.0mm		0hr					No data
0700	5.3°C	77.6%	0.0mm		0hr					No data
0800	5.2°C	79.8%	0.0mm		0hr					No data
0900	4.1°C	88%	0.8mm		0hr					No data
1000	3.3°C	93.1%	1.8mm		0hr					No data
1100	3.2°C	95.8%	2.6mm		0hr					No data
1200	3.5°C	97.2%	2.8mm		0hr					No data
1300	4.3°C	98.6%	2.6mm		0hr					data
1400	10.0°C	100%	2.4mm		0hr					
1500	11.2°C	91.7%	1.6mm		0hr					No
1600	11.7°C	89.9%	1.6mm		0hr					No da
1700	11.7°C	92.4%	1.6mm		0h					No data
1800	3.6°C	93.8%	2.6mm		0hr					No data
1900	3.0°C	94.5%	1.2mm		0hr					No data
2000	2.9°C	96.5%	0.0mm		0hr					No data
2100	3.3°C	94.5%	0.0mm		0hr					No data
2200	3.1°C	93.8%	0.0mm		0hr					No data
2300	3.5°C	94.5%	0.0mm		0hr					No data
2400	3.8°C	93.8%	0.0mm		0hr					No data
Totals			21.6mm		0hr					



Weather at Sheffield (131m ASL) 8.2 miles SW of S65 3SR (20m ASL)
Sunday 13 December 2015

GMT	Air Temp	Humidity	Rain	Visibility	Sun	Cloud Cover	Wind From	Mean Wind	Max Gust	Weather
0100	3.3°C	94.5%	0.0mm		0hr					No data
0200	2.4°C	94.4%	0.0mm		0hr					No data
0300	2.8°C	95.1%	0.0mm		0hr					No data
0400	1.9°C	95.8%	0.0mm		0hr					No data
0500	1.1°C	97.2%	0.0mm		0hr					No data
0600	1.1°C	97.9%	0.0mm		0hr					No data
0700	0.9°C	99.3%	0.0mm		0hr					No data
0800	0.6°C	99.3%	0.0mm		0hr					No data
0900	1.0°C	99.3%	0.0mm		0hr					No data
1000	1.5°C	100%	0.0mm		0hr					No data
1100	2.7°C	100%	0.0mm		0hr					No data
1200	3.6°C	95.2%	0.0mm		0hr					data
1300	4.0°C	95.9%	0.2mm		0hr					ata
1400	4.1°C	95.9%	0.0mm		0hr					N
1500	4.1°C	98.6%	0.8mm		0hr					No d
1600	4.1°C	99.3%	0.6mm		0hr					No dat
1700	4.2°C	99.3%	0.4mm		0hr					No data
1800	4.4°C	99.3%	0.2mm		0hr					No data
1900	4.5°C	99.3%	0.0mm		0hr					No data
2000	4.6°C	99.3%	0.0mm		0hr					No data
2100	4.9°C	100%	0.0mm		0hr					No data
2200	5.1°C	99.3%	0.0mm		0hr					No data
2300	5.3°C	99.3%	0.0mm		0hr					No data
2400	6.1°C	98.6%	0.0mm		0hr					No data
Totals			2.2mm		0.					

Air Temperature (°C)



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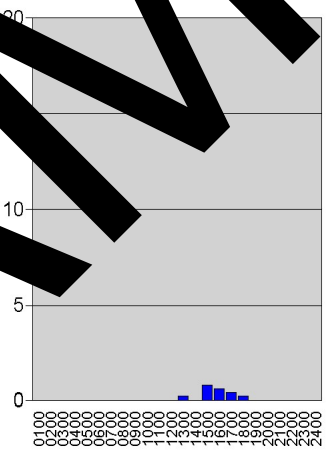
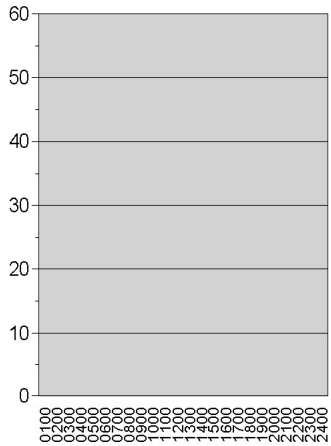


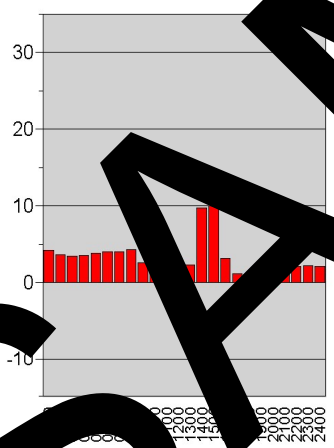
Mean Wind & Gust (kt)



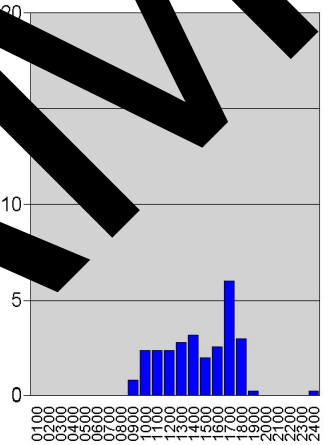
Weather at Emley Moor No 2 (267m ASL) 18 miles NW of S65 3SR (20m ASL)
Saturday 12 December 2015

GMT	Air Temp	Humidity	Rain	Visibility	Sun	Cloud Cover	Wind From	Mean Wind	Max Gust	Weather
0100	4.2°C	88.1%	0.0mm				260°	15kt	24kt	No data
0200	3.6°C	89.3%	0.0mm				260°	12kt	19kt	No data
0300	3.4°C	89.2%	0.0mm				250°	12kt	21kt	No data
0400	3.5°C	86.7%	0.0mm				240°	13kt	21kt	No data
0500	3.8°C	84.9%	0.0mm				250°	16kt	24kt	No data
0600	4.0°C	84.3%	0.0mm				250°	10kt	16kt	No data
0700	4.0°C	83.1%	0.0mm				180°	4kt	7kt	No data
0800	4.3°C	76.8%	0.0mm				200°	8kt	14kt	No data
0900	2.6°C	92.4%	0.8mm				160°	10kt	14kt	No data
1000	1.3°C	97.9%	2.4mm				130°	15kt	[illegible]	No data
1100	1.4°C	100%	2.4mm				130°	21kt	[illegible]	No data
1200	1.9°C	100%	2.4mm				130°	22kt	[illegible]	[illegible]data
1300	2.3°C	100%	2.8mm				130°	11kt	27kt	[illegible]
1400	9.7°C	100%	3.2mm				230[illegible]	[illegible]	33kt	[illegible]
1500	10.0°C	96.1%	2.0mm				[illegible]	[illegible]	[illegible]kt	No [illegible]
1600	3.2°C	92.5%	2.6mm				[illegible]°	10kt	[illegible]t	No data
1700	1.2°C	99.3%	6.0mm				020°	12kt	[illegible]	No data
1800	1.1°C	100%	3.0mm				350°	9kt	[illegible]	No data
1900	1.3°C	100%	0.2mm				350°	9kt	[illegible]t	No data
2000	1.6°C	99.3%	0.0mm				330°	8[illegible]	[illegible]kt	No data
2100	1.9°C	100%	0.0mm				[illegible]30°	[illegible]	13kt	No data
2200	2.1°C	99.3%	0.0mm				[illegible]°	[illegible]t	8kt	No data
2300	2.2°C	100%	0.0mm				[illegible]	5kt	8kt	No data
2400	2.1°C	100%	0.2mm				31[illegible]	[illegible]kt	10kt	No data
Totals			28.0mm							

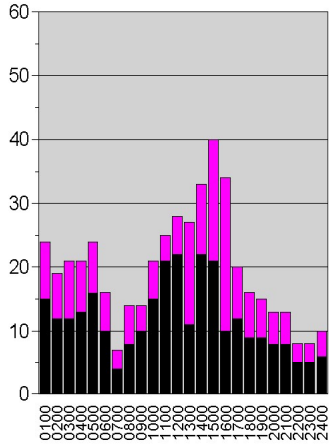
Air Temperature (°C)



[illegible]fall (m[illegible]

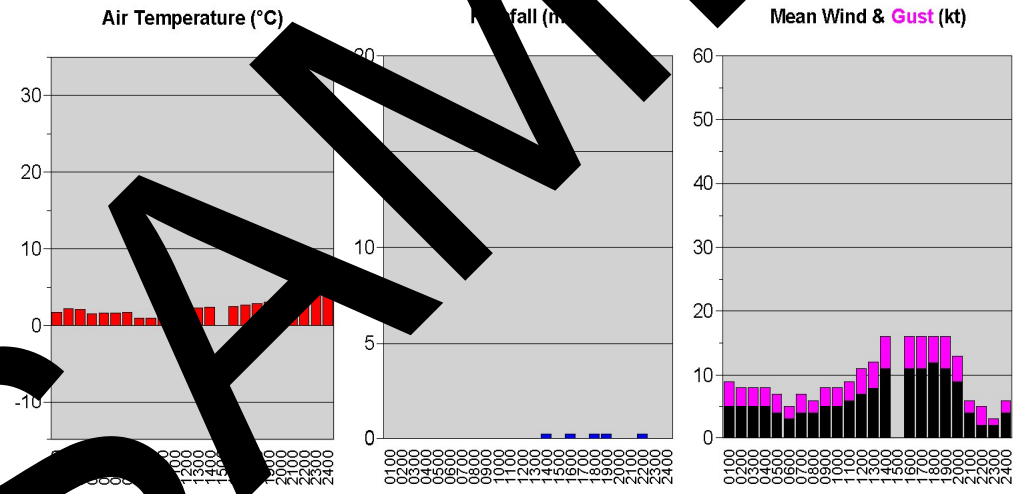


Mean Wind & Gust (kt)



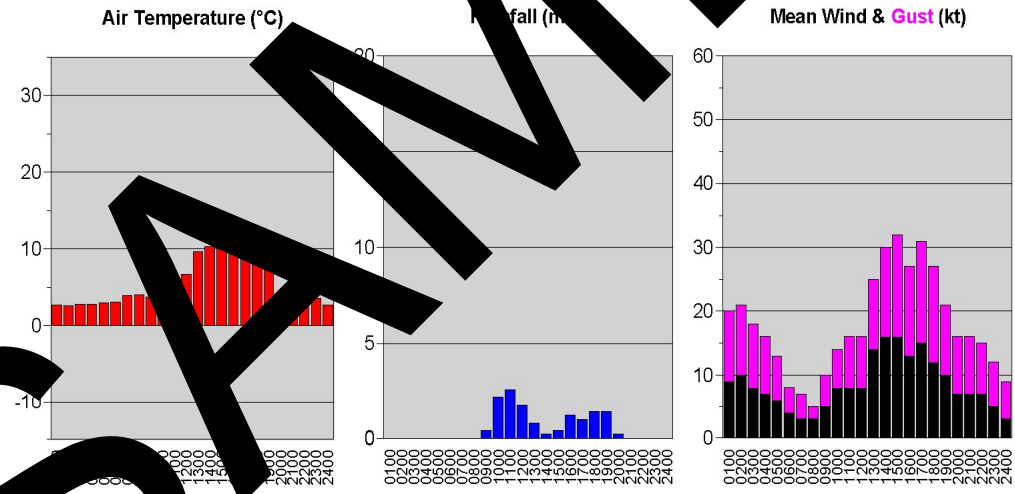
Weather at Emley Moor No 2 (267m ASL) 18 miles NW of S65 3SR (20m ASL)
Sunday 13 December 2015

GMT	Air Temp	Humidity	Rain	Visibility	Sun	Cloud Cover	Wind From	Mean Wind	Max Gust	Weather
0100	1.7°C	100%	0.0mm				280°	5kt	9kt	No data
0200	2.2°C	97.2%	0.0mm				320°	5kt	8kt	No data
0300	2.1°C	96.5%	0.0mm				320°	5kt	8kt	No data
0400	1.5°C	97.2%	0.0mm				310°	5kt	8kt	No data
0500	1.6°C	95.8%	0.0mm				320°	4kt	7kt	No data
0600	1.6°C	95.8%	0.0mm				360°	3kt	5kt	No data
0700	1.7°C	94.4%	0.0mm				050°	4kt	7kt	No data
0800	1.0°C	95.8%	0.0mm				120°	4kt	6kt	No data
0900	1.0°C	97.2%	0.0mm				120°	5kt	8kt	No data
1000	1.4°C	96.5%	0.0mm				110°	5kt	[illegible]	No data
1100	1.9°C	97.2%	0.0mm				120°	6kt	[illegible]	No data
1200	2.0°C	97.9%	0.0mm				120°	7kt	11[illegible]	[illegible] data
1300	2.3°C	99.3%	0.0mm				120°	8kt	12kt	[illegible]
1400	2.4°C	100%	0.2mm				120[illegible]		16kt	N[illegible]
1500										No d[illegible]
1600	2.5°C	100%	0.2mm				[illegible]°	11kt	[illegible]t	No data
1700	2.7°C	100%	0.0mm				120°	11kt		No data
1800	2.9°C	100%	0.2mm				120°	12kt		No data
1900	3.1°C	100%	0.2mm				130°	11kt	[illegible]t	No data
2000	3.3°C	100%	0.0mm				140°	9[illegible]	[illegible]kt	No data
2100	3.6°C	100%	0.0mm				120°		6kt	No data
2200	3.7°C	100%	0.2mm				[illegible]°	[illegible]t	5kt	No data
2300	4.7°C	100%	0.0mm				[illegible]	2kt	3kt	No data
2400	4.8°C	100%	0.0mm				190	[illegible]kt	6kt	No data
Totals			1.0mm							



Weather at Nottingham, Watnall (117m ASL) 30.8 miles S of S65 3SR (20m ASL)
Saturday 12 December 2015

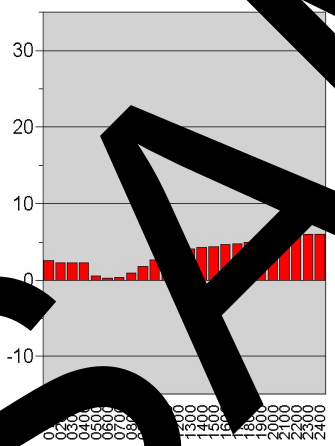
GMT	Air Temp	Humidity	Rain	Visibility	Sun	Cloud Cover	Wind From	Mean Wind	Max Gust	Weather
0100	2.7°C	89.2%	0.0mm	8km	0hr	0%	230°	9kt	20kt	None
0200	2.6°C	89.2%	0.0mm	19km	0hr	50%	230°	10kt	21kt	None
0300	2.8°C	89.2%	0.0mm	15km	0hr	87.5%	230°	8kt	18kt	None
0400	2.8°C	89.2%	0.0mm	16km	0hr	100%	230°	7kt	16kt	None
0500	3.0°C	90.5%	0.0mm	10km	0hr	100%	230°	6kt	13kt	None
0600	3.1°C	91.2%	0.0mm	24km	0hr	100%	220°	4kt	8kt	None
0700	3.9°C	88%	0.0mm	30km	0hr	100%	210°	3kt	7kt	None
0800	4.0°C	86.8%	0.0mm	10km	0hr	87.5%	100°	3kt	5kt	None
0900	3.7°C	93.8%	0.4mm	8km	0hr	87.5%	100°	5kt	10kt	Slight rain
1000	3.5°C	96.5%	2.2mm	4.8km	0hr	75%	110°	8kt	[illegible]	Moderate rain
1100	4.3°C	98.6%	2.6mm	4.4km	0hr	87.5%	130°	8kt	[illegible]	Moderate rain
1200	6.7°C	100%	1.8mm	3.6km	0hr	87.5%	160°	8kt	16[illegible]	[illegible]derate rain
1300	9.6°C	94.8%	0.8mm	6km	0hr	75%	200°	14kt	25kt	
1400	10.3°C	93.5%	0.2mm	7km	0hr	75%	210[illegible]	[illegible]	30kt	Sl[illegible]in showers
1500	10.7°C	93.5%	0.4mm	6km	0hr	87.5%	[illegible]	[illegible]	[illegible]kt	Rain
1600	10.8°C	94.8%	1.2mm	3.2km	0hr	87.5%	[illegible]	13kt	[illegible]	Slight [illegible]owers
1700	11.6°C	91.1%	1.0mm	10km	0hr	87.5[illegible]	230°	15kt	[illegible]	Moderate
1800	11.4°C	94.8%	1.4mm	5km	0hr	87[illegible]	230°	12kt	[illegible]	Slight rain
1900	10.0°C	88.6%	1.4mm	10km	0hr	[illegible]%	290°	10kt	[illegible]t	Rain
2000	3.8°C	93.2%	0.2mm	30km	0hr	[illegible]	340°	7[illegible]	[illegible]kt	Rain
2100	3.5°C	93.8%	0.0mm	12km	0hr	87.5[illegible]	[illegible]30°	[illegible]	16kt	Haze
2200	3.6°C	93.2%	0.0mm	8km	0hr	87.5%	[illegible]°	[illegible]	15kt	None
2300	3.5°C	92.5%	0.0mm	21km	0hr	87.5%	[illegible]	[illegible]5kt	12kt	None
2400	2.7°C	95.8%	0.0mm	10km	0hr	[illegible]2.5%	32[illegible]	[illegible]8kt	9kt	Mist
Totals			13.6mm		0.[illegible]					



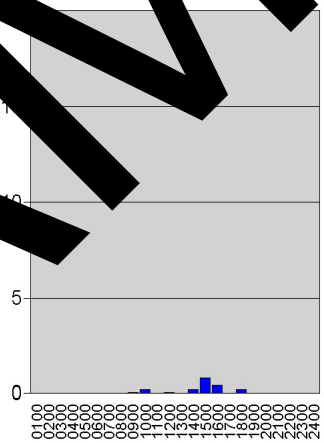
Weather at Nottingham, Watnall (117m ASL) 30.8 miles S of S65 3SR (20m ASL)
Sunday 13 December 2015

GMT	Air Temp	Humidity	Rain	Visibility	Sun	Cloud Cover	Wind From	Mean Wind	Max Gust	Weather
0100	2.6°C	96.5%	0.0mm	24km	0hr	87.5%	320°	4kt	11kt	Mist
0200	2.3°C	95.1%	0.0mm	6km	0hr	75%	320°	2kt	6kt	Mist
0300	2.3°C	97.9%	0.0mm	9km	0hr	100%	340°	3kt	8kt	Mist
0400	2.3°C	97.9%	0.0mm	7km	0hr	100%	010°	4kt	8kt	Mist
0500	0.6°C	95.7%	0.0mm	4.4km	0hr	87.5%	030°	4kt	8kt	Mist
0600	0.3°C	96.4%	0.0mm	3.5km	0hr	87.5%	040°	3kt	5kt	Mist
0700	0.4°C	99.3%	0.0mm	3.3km	0hr	87.5%	020°	2kt	4kt	Mist
0800	1.0°C	99.3%	0.0mm	8km	0hr	100%	050°	3kt	6kt	Mist
0900	1.8°C	99.3%	0.05mm	5km	0hr	87.5%	060°	4kt	8kt	Slight-moderate precipitation
1000	2.7°C	98.6%	0.2mm	6km	0hr	100%	060°	4kt		Rain
1100	3.2°C	98.6%	0.0mm	5km	0hr	87.5%	070°	3kt	6kt	
1200	3.8°C	97.9%	0.05mm	3.5km	0hr	87.5%	060°	5kt	9kt	
1300	4.1°C	97.9%	0.0mm	3.2km	0hr	62.5%	080		7kt	M
1400	4.3°C	99.3%	0.2mm	1.6km	0hr	87.5%			kt	Rain
1500	4.4°C	99.3%	0.8mm	1.4km	0hr	100%	0°	6kt	t	Rain
1600	4.7°C	100%	0.4mm	2km	0hr	100	100°	6kt		Rain
1700	4.8°C	100%	0.0mm	1.3km	0hr	1	120°	5kt	t	Mist
1800	5.0°C	100%	0.2mm	400m	0hr	%	120°	4kt	kt	Fog - thickenin
1900	5.1°C	100%	0.0mm	200m	0hr		110°	4	8kt	Fog - thickening
2000	5.3°C	100%	0.0mm	200m	0hr		40°		6kt	Fog - static
2100	5.5°C	100%	0.0mm	100m		87.5%	°	t	7kt	Fog - static
2200	5.7°C	100%	0.0mm	100m				2kt	4kt	Fog - static
2300	6.0°C	100%	0.0mm	400m		7.5%	140	3kt	7kt	Fog - thinning
2400	6.0°C	100%	0.0mm	300m		%	100°		5kt	Fog - thickening
Totals			1.9mm		0.0					

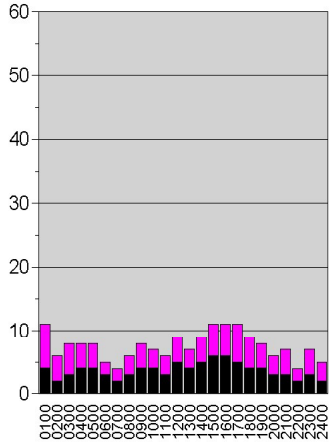
Air Temperature (°C)



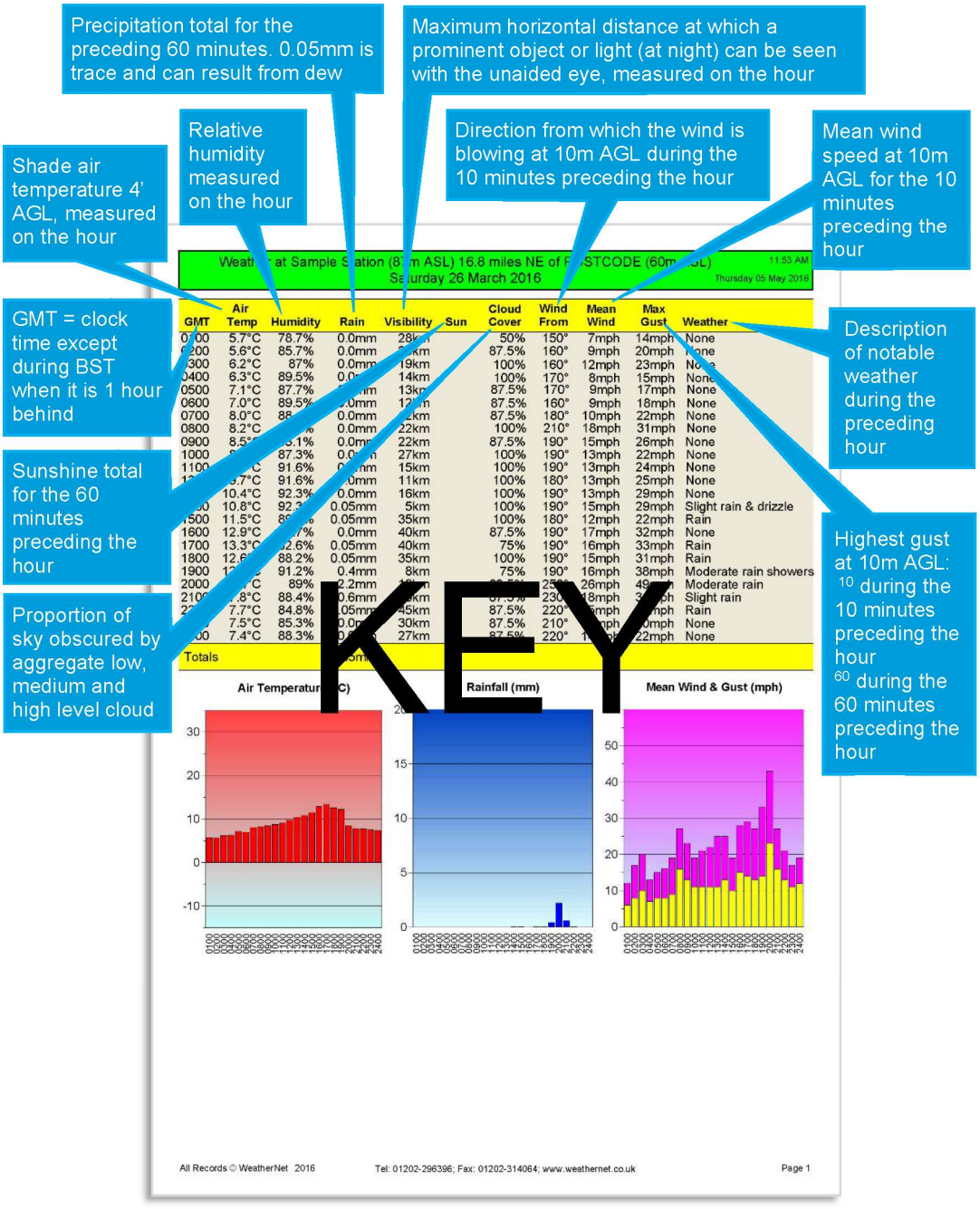
Rainfall (mm)



Mean Wind & Gust (kt)

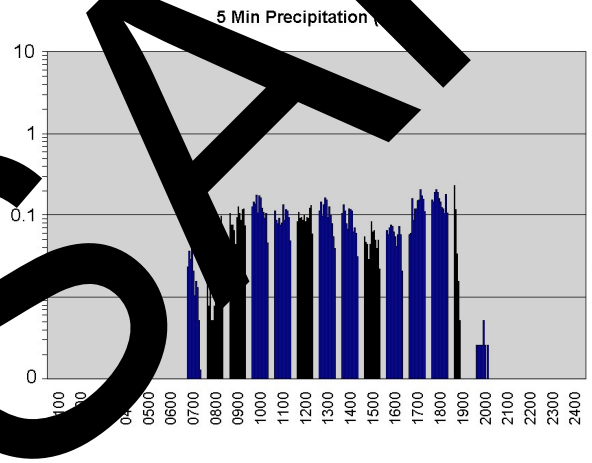


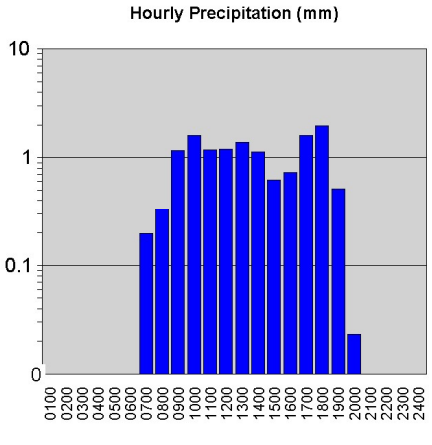
Hourly Station Data - Key



Radar Precipitation Report for S65 3SR
Saturday 12 December 2015

GMT	Precipitation (mm) for 5 minutes ending 05	10	15	20	25	30	35	40	45	50	55	60	Hourly Total* (mm)
0001-0100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0101-0200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0201-0300	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0301-0400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0401-0500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0501-0600	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0601-0700	0.000	0.000	0.023	0.037	0.029	0.042	0.021	0.010	0.006	0.013	0.005	0.003	0.1
0701-0800	0.016	0.008	0.013	0.005	0.005	0.008	0.013	0.016	0.0	0.050	0.096	0.143	0.333
0801-0900	0.104	0.075	0.075	0.065	0.044	0.094	0.130	0.104	0.086	20	0.122	0.148	1.167
0901-1000	0.130	0.148	0.141	0.180	0.109	0.177	0.167	0.1	0.112	0	0.104	0.091	1.4
1001-1100	0.115	0.086	0.078	0.091	0.075	0.081	0.13	0.0	30	0.11	94	0.096	72
1101-1200	0.083	0.112	0.091	0.094	0.086	0.099	0	0.094	0	0.125	5	0.1	1.201
1201-1300	0.115	0.148	0.096	0.138	0.167	0.156	94	0.130	0.1	0.078	0.0	8	1.376
1301-1400	0.104	0.138	0.115	0.078	0.068	0.1	0.120	0.115	0	0.070	0.060	063	1.123
1401-1500	0.055	0.047	0.044	0.029	0.044	0.085	63	0.065	050	0.039	0.050	0.044	0.621
1501-1600	0.065	0.057	0.070	0.075	0.0	0.063	0	0.0	0.057	0.073	0.057	0.042	0.731
1601-1700	0.057	0.060	0.164	0.086	0	122	0.15	6	0.208	0.177	0.162	0.227	1.603
1701-1800	0.156	0.148	0.195	0.208	0.1	4	0.148		0.122	0.107	0.182	0.216	1.974
1801-1900	0.234	0.120	0.034	0.016	0.00	0.0	000	0.0	000	0.000	0.000	0.000	0.517
1901-2000	0.003	0.003	0.003	0.003	0.003	005	3	0.000	3	0.000	0.000	0.000	0.023
2001-2100	0.000	0.000	0.000	0.000	0.000	00	0.	0.000	0.000	0.000	0.000	0.000	0.000
2101-2200	0.000	0.000	0	000	0.000	0	0.000	0	0.000	0.000	0.000	0.000	0.000
2201-2300	0.000	0.000	0	0.	000	0.0	0.000	0	0.000	0.000	0.000	0.000	0.000
2301-2400	0.000	0.000	0.00	000	0	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0001 - 2400 Total (mm)													13.641





*NB:The 12 5-minute precipitation totals may not exactly match the hourly total. The latter are calculated using a more precise 'trapezium' rule.

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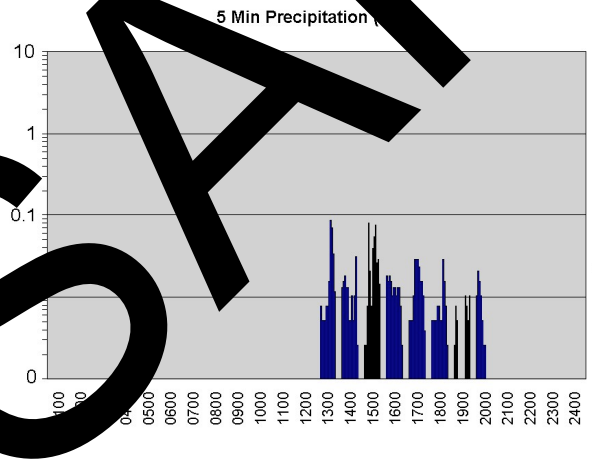
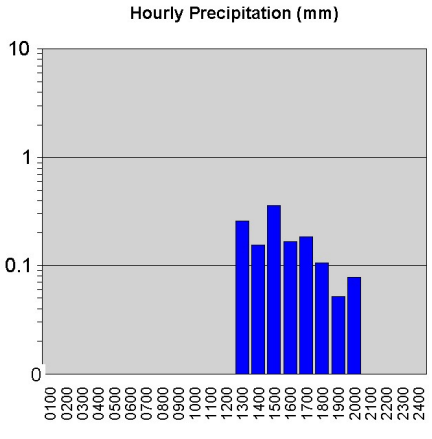
Radar Precipitation Report for S65 3SR
Sunday 13 December 2015

GMT	Precipitation (mm) for 5 minutes ending 05	10	15	20	25	30	35	40	45	50	55	60	Hourly Total* (mm)
0001-0100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0101-0200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0201-0300	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0301-0400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0401-0500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0501-0600	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0601-0700	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0701-0800	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0801-0900	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0901-1000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1001-1100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1101-1200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1201-1300	0.000	0.008	0.005	0.005	0.005	0.008	0.008	0.016	0.000	0.070	0.000	0.000	0.256
1301-1400	0.013	0.016	0.018	0.013	0.013	0.000	0.005	0.010	0.000	0.010	0.031	0.005	0.155
1401-1500	0.003	0.003	0.008	0.081	0.021	0.008	0.039	0.055	0.075	0.026	0.029	0.029	0.363
1501-1600	0.018	0.016	0.018	0.016	0.000	0.013	0.000	0.000	0.013	0.013	0.008	0.005	0.165
1601-1700	0.005	0.005	0.005	0.010	0.000	0.029	0.021	0.023	0.016	0.016	0.010	0.008	0.184
1701-1800	0.005	0.005	0.005	0.005	0.000	0.008	0.005	0.000	0.029	0.016	0.008	0.005	0.105
1801-1900	0.003	0.008	0.005	0.000	0.000	0.000	0.000	0.000	0.010	0.008	0.005	0.021	0.052
1901-2000	0.010	0.021	0.016	0.010	0.005	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.078
2001-2100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2101-2200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2201-2300	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2301-2400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0001 - 2400 Total (mm)													1.359





*NB:The 12 5-minute precipitation totals may not exactly match the hourly total. The latter are calculated using a more precise 'trapezium' rule.

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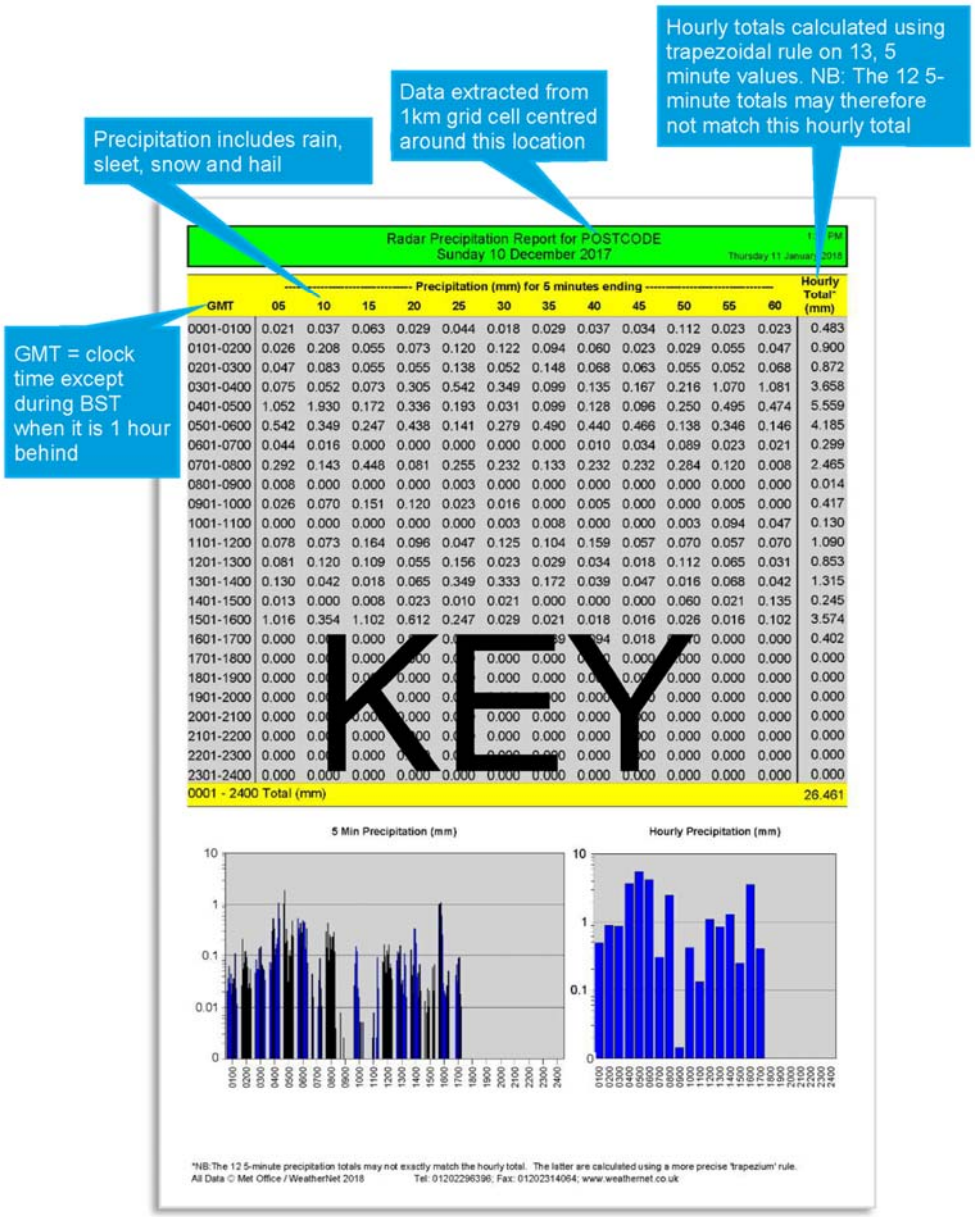
Hourly Rainfall Radar Data - Key



Weather for 50km around S65 3SR
12/12/2015 - 14/12/2015

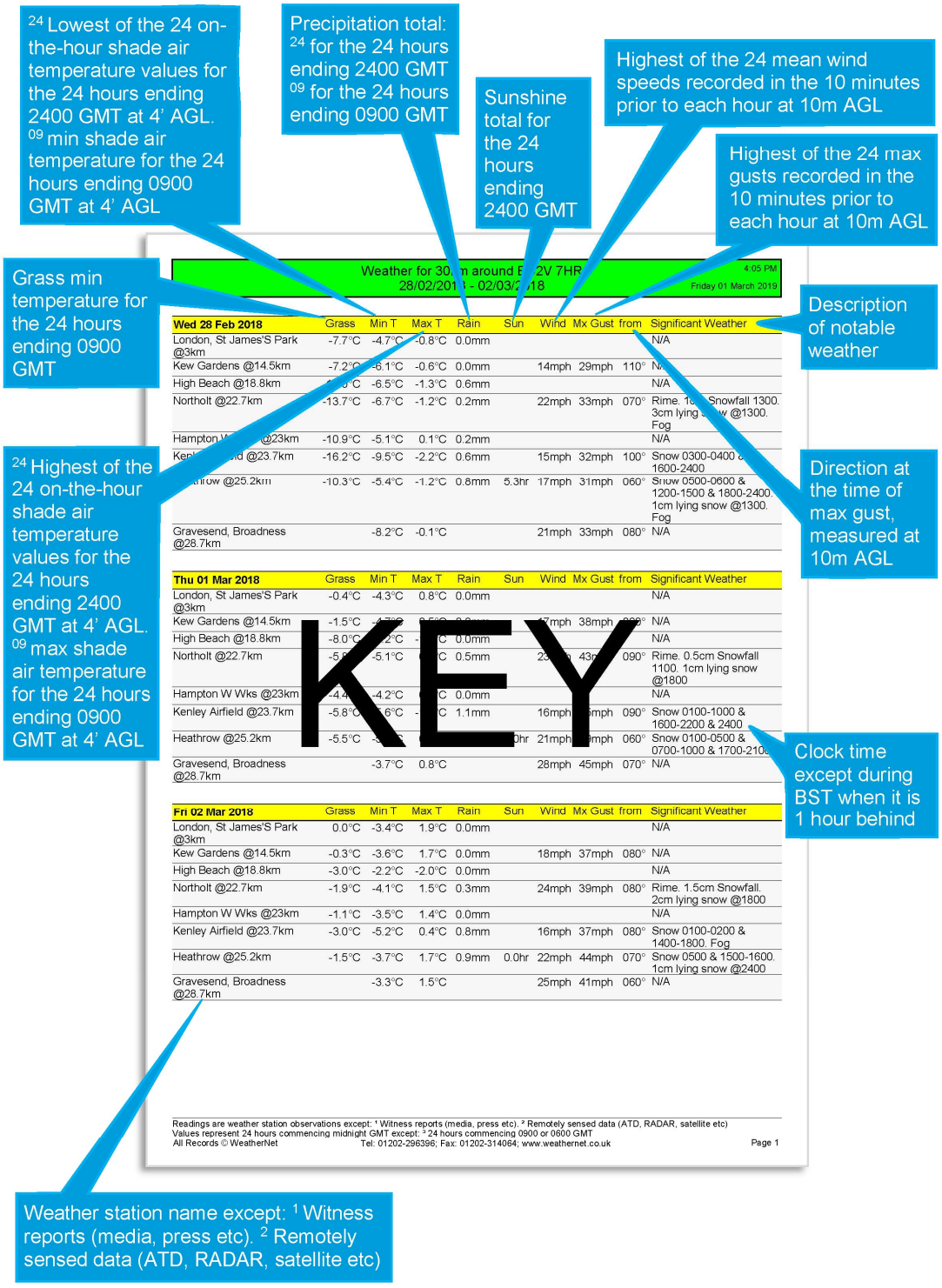
Sat 12 Dec 2015	Grass	Min T	Max T	Rain	Sun	Wind	Mx Gust	from	Significant Wea
Sheffield @13.3km	0.8°C	4.1°C	11.8°C	21.6mm	0.0hr				N/A
Ryhill @20.4km	2.5°C	4.1°C	7.3°C	19.6mm					5mm ra hour from 1600
Emley Moor No. 2 @29km	2.1°C	2.6°C	10.2°C	28.0mm		25mph	46mph	250°	6mm r hour from 1600
Gringley-On-The-Hill @29.8km	0.9°C	3.0°C	11.3°C	15.2mm					5.2mm rain 1700
Middleton, Hillside @42.7km					0.0hr	22mph	38mph	180°	Sleet early hours.
Bramham @46.7km	-0.2°C	3.5°C	4.8°C	20.4mm		18mph	28mph	120°	N/A
Normanby Hall @48.9km	0.7°C	2.3°C	10.7°C	12.6mm					N/A
Nottingham, Watnall @49.6km	0.6°C	2.5°C	11.8°C	13.6mm	0.0hr	18mph	3	220°	None

Sun 13 Dec 2015	Grass	Min T	Max T	Rain	S	Wind	Gust	from	ificant Weat
Sheffield @13.3km	-4.3°C	0.5°C	7.3°C	2.2mm	hr				
Ryhill @20.4km	-2.7°C	0.6°C	7.0°C	1.7m					N/A
Emley Moor No. 2 @29km	-1.5°C	0.8°C	7.2°C	1		14mph	ph	130°	N/A
Gringley-On-The-Hill @29.8km	-2.5°C	0.6°C	6.8°C	1.8					N/A
Middleton, Hillside @42.7km						ph	15mph	135°	Fog
Bramham @46.7km	-3.9°C	-0.8°C		2mm		mph	12mph	290°	N/A
Normanby Hall @48.9km	-5.5°C	-1.5°C	7	m					N/A
Nottingham, Watnall @49.6km	-3.2°C	0.0°C	7.6	1.9	0.0hr	7	3mph	320°	Fog

Mon 14 Dec 2015		Min T	Max T	n	Su	Wind	Mx Gust	from	Significant Weather
Sheffield @13.3km			8.4°C	1 m	0.0hr				N/A
Ryhill @20.4km	3.	0.9°C		0.8					N/A
Emley Moor No. 2 @29km	2.8°C	°C	7.4			13mph	21mph	200°	N/A
Gringley-On-The-Hill @29.8km	4.7°C		8.0°C	0.0					N/A
Middleton, H					0.0hr	9mph	16mph	135°	N/A
Bramham @4 m		°C	-0.8°C	0.2mm		8mph	14mph	150°	N/A
Normanby Hall	.9km		°C	7.9°C	0.0mm				N/A
Nottingham, Wat @49.6km		°C		6.2°C	0.8mm	0.0hr	8mph	17mph	160° Fog

Readings are weather station observations except: [1] Witness reports (media, press etc). [2] Remotely sensed data (ATD, RADAR, satellite etc)
Values represent 24 hours commencing midnight GMT except: [3] 24 hours commencing 0900 or 0600 GMT
 Tel: 01202-296396; Fax: 01202-314064; www.weathernet.co.uk

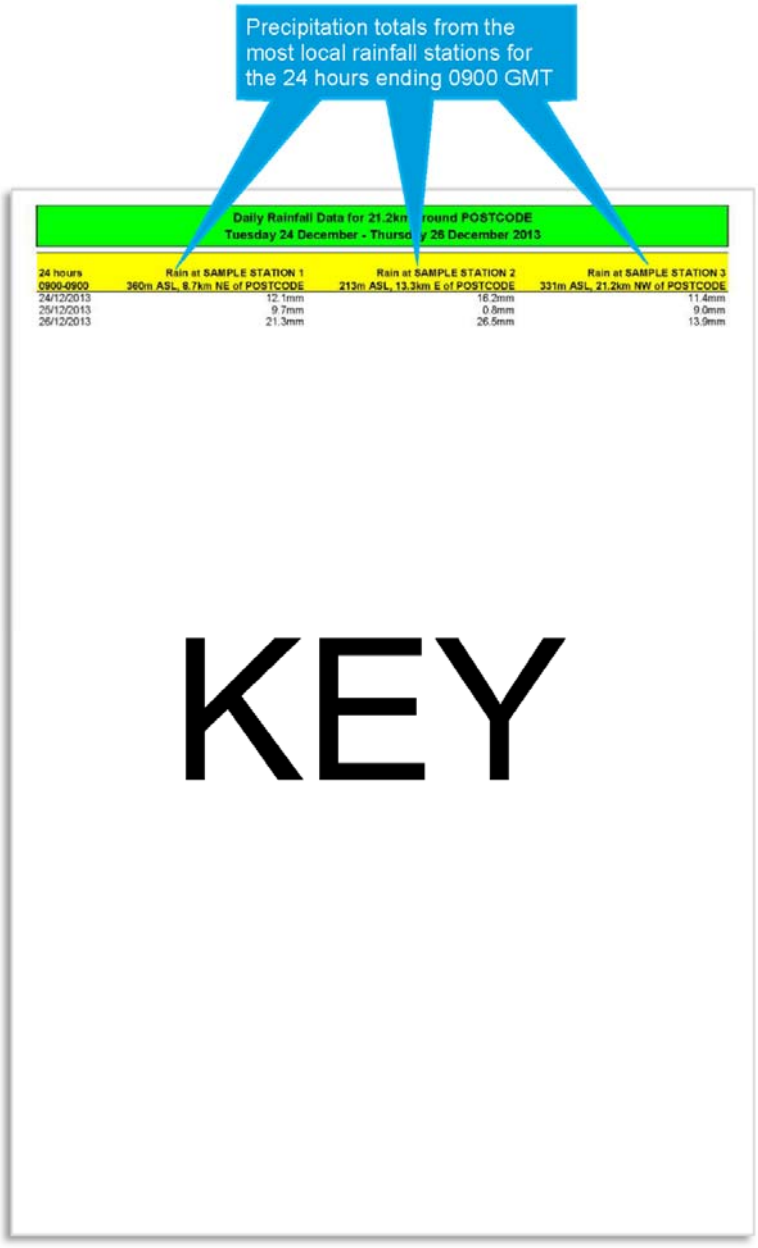
Daily Station Data - Key



Daily Rainfall Data for 10km around S65 3SR
Sunday 13 December 2015

Daily Rainfall Station	Rainfall (mm)
Rotherham, Templebrook	N/A

Daily Rainfall Station Data - Key



Beaufort Scale

Beaufort Force	Description	Mean Speed (mph)	Lower Limit (mph)	Upper Limit (mph)	Specification on Land
0	Calm	0	0	1	Calm; smoke rises vertically
1	Light Air	2	1	3	Direction of wind shown by smoke drift but no[t] [w]ind vanes
2	Light Breeze	5	4	7	Wind felt on face; leaves rustle
3	Gentle Breeze	10	8	12	Leaves & small twigs in constant motion; wind exten[ds] flag
4	Moderate Breeze	15	13	18	Dust & loose paper raised; small branches moved
5	Fresh Breeze	21	18	24	Small trees in leaf begin[] [s]way; crested wavelets form on water
6	Strong Breeze	27	24	31	Large branches in motion; whi[] heard in telegraph wires
7	Near Gale	35	31	38	Whole trees [in] motion; inconvenie[nce] felt when walking [a]gainst the wind
8	Gale	42	39	46	Twigs [br]eak off trees; di[ff]icult to walk ag[ainst] wind
9	Strong Gale	50	47	54	Sl[ight] structural damage [occurs,] chimney pots, a[nd] [s]lates of slates
10	Storm	59	55	63	[T]rees uprooted; consid[era]ble structural damage
11	Violent Storm	68	64	72	Wi[de]spread structu[ral] damage
12	Hurricane	-	73	-	Devast[ation]

Anecdotal evidence

No anecdotal reports were included in this meteorological report.

Sun & moon data

On the 12th December 2015: Sunrise 08:11, Sunset 15:46, Moonrise 0[illegible], Moonset 17:18. Phase of Moon: Waxing Crescent. All times are uni[illegible]sal.
On the 13th December 2015: Sunrise 08:12, Sunset 15:46, Moon[illegible]09:23, Moonset 18:17. Phase of Moon: Waxing Crescent. All times are u[illegible]rsal.

Interview & examination

None were conducted for this meteorological report.

Research papers

None were consulted for this meteorological r[illegible]t.

Measurement tests & experiments

None were conducted for this mete[illegible]gical report.

The Author

I am the Chief Meteorologist at WeatherNet Ltd. WeatherNet Ltd is a subsidiary of Sedgwick International UK. I have been employed by WeatherNet Ltd since the 10th July 1997. My qualifications include a BSc (Hons) in Geography (2:1) (obtained June 1994), while in July 1997, I obtained a City and Guilds certificate in Teaching (stage 1) in further and adult education. In July 2005, I obtained a PhD investigating the spatial and temporal analysis of heavy snowfalls across Great Britain between the years 1861-1999.

I am a Fellow of the Royal Meteorological Society (since October 1990), a Member of the National Geographic Society (since January 1993), a Member of the Association of British Climatologists (since January 1995) and a Fellow of the Royal Geographical Society (since January 2005). I have produced forty research articles about snow/snowfalls/blizzards/weather in general in several academic publications (including the Journal of Meteorology and Weather) and four books since 1995. I have also made numerous talks at Universities, had radio chats with quotes for local/national radio, TV and newspapers. Finally, I have been credited and/or acknowledged to have helped on over 50 films and various TV programmes including Spectre, Harry Potter and the Deathly Hallows: Part 1/2, Alice Through The Looking Glass and Star Wars: The Force Awakens.

I am also a staff member of TORRO (Tornado and Storm Research Organisation (based at Oxford Brookes University)). My role is Research Leader of Heavy Snowfalls which is part of the Thunderstorm and Severe Weather Division and I have held this post since 1998.

To date, I have prepared more than 2,000 legal meteorological reports since the year 2000 and in the last five years, I have given evidence in court on three occasions (July 2015, May 2017 and October 2017).

I am (in association with WeatherNet Ltd) currently listed as an expert witness on several expert witness websites including www1.orcexperts.com, https://trexpertwitness.com/, www.justicedirectory.co.uk, https://legalexperts-uk.com/, www.lawpages.com, www.insurance-directories.com, www.expertwitness.co.uk, www.witnessdirectory.com, www.thesolicitorsgroup.co.uk, www.publiclawtoday.co.uk and www.hgexperts.com.

I was (in association with WeatherNet Ltd) vetted by the Expert Witness Directory (www.legalhub.co.uk/legalhub/app/appinit) between January 2005 and October 2017.

Since September 2010, I have been included on the National Crime Agency (NCA) (www.nationalcrimeagency.gov.uk).

Affiliations

Dr Richard Wild, Chief Meteorologist, has over 20 years of experience and, in association with WeatherNet, is listed as an expert witness on several exp witness websites.

Dr Richard Wild, Chief Meteorologist, in association with Weathe t, has also been vetted or gained membership of the following:

https://www.csofs.org/ (since June 2009)

https://www.expertwitnes ert/57 7e2ca2f2 228b5 cc7 (since May 2012)

https://www.academyo nert g/find-an-expert (since June)

https://www.ne .ex /expert richard-wild/consultant-meteorologist/bo emo E20 (since January 2018)

https: ww.apil find-an-expert (since April 2007)

ispubs.com/index.htm (since February 2017)

https://www.lawscot.org.uk/WCM/ExpertWitnessProfile?ID=23797bca-eea7-45b1-9d4b-68aba1ad2e83 (since November 2016)

Dr Richard Wild, Chief Meteorologist was 'trained in the aspects of report writing' in July 2008 and the 'Jackson Reforms' in May 2013 by Bond Solon. All legal weather reports comply with this training.

https://www.bondsolon.com/

Explanatory notes

General

All meteorological ground-based readings presented in this report have been made using acknowledged instrumentation and in accordance with procedures laid down by the World Meteorological Organisation (WMO). All meteorological readings in this report have been subject to careful quality control by Weathernet Ltd. All times shown is Greenwich Mean Time (GMT) unless otherwise stated. The times will be 1-hour BEHIND clock time for the period late March-late October when British Summer Time (BST) is in operation in the United Kingdom.

The meteorological instrument enclosure

Most meteorological instruments at ground based meteorological stations are in an enclosure, a flat area of ground approximately 10 metres by 7 metres covered by short grass and surrounded by fencing. The enclosure should be well away from trees or any other large obstructions. The distance to any object should be not less than twice the height of the object, and preferably four times the height.

Ground based meteorological stations

At most ground based meteorological stations; meteorological observations of the highest integrity are made by professional meteorological observers on a routine hourly basis throughout the 24-hour day, 365 days a year. Many meteorological parameters are monitored by automatic equipment (SAWS, SAMOS, CDL) and during periods when (some) ground based meteorological stations are unmanned, evaluations of certain meteorological parameters (present weather, visibility for example) go unrecorded. Certain other ground based meteorological stations (i.e. Auxiliary Meteorological Stations (e.g. Coastguard Stations)) only make routine meteorological observations at certain fixed times of the day - often at 3-hourly intervals. At co-operating Climatological Stations, the meteorological observer normally makes only one routine meteorological observation per day at 0900 GMT. This meteorological observation represents the past 24 hour's e.g. maximum and minimum air temperatures, rainfall, state of ground, sunshine etc. Not all ground based meteorological stations record all meteorological parameters. They are manned by a large variety of persons and in some cases the meteorological observer is available to monitor certain meteorological elements during the daytime, recording a very brief description in the form of a diary. At rainfall stations only, the previous days' 24-hour daily rainfall reading is taken at 0900 GMT.

Significant weather

Significant weather includes details of the occurrence of air and ground (grass) frosts; gales; details of any heavy or continuous rain; fog; freezing rain; hail; sleet; snow; lying snow; thunder, lightning; squalls and tornadoes to occur at the ground

based meteorological station in the 24-hours ending midnight. ‘None’ means that none of these types of weather occurred. ‘X’ means that no meteorological observation of weather was made.

Rainfall

The enemies of rainfall measurement are wind and in-splashing. W[illegible] blows rain drops around a rain gauge and therefore the lower the rim (and t[illegible]fore the better the wind) the better. However, if the rim of the rain gauge is too clos[illegible] th[illegible]ound then in-splashing occurs. As a compromise, the standard rain gauge h[illegible] rim 30cm above the ground. The diameter is 5 inches (127mm) and rainfall ca[illegible]e measured to a resolution of 0.1mm. From a tipping [illegible]cket rain gauge perspe[illegible] this does not provide details of the timing of small am[illegible]ts of rain. A tip of the r[illegible] gauge may be triggered in one hour when most of the ra[illegible]ll in a previous hour. Rainfall (noted in millimetres and tenths), in[illegible]y soli[illegible]cipitation[illegible]h as snow or hail which is melted and measu[illegible]n the s[illegible]e way a[illegible]in. T[illegible]e may also be small additions due to deposi[illegible] of dew, ho[illegible]rost and [illegible]e on the collecting surface of the rain gauge. [illegible]fall amou[illegible] of <0.05mm are usually recorded as 'trace'. In some instances, [illegible] auto[illegible]tic meteorological equipment, precipitation amounts less th[illegible]mm (i.e[illegible]w spots) will not be registered. Many rainfall stations in the U[illegible]ted on w[illegible]r Authority property, at reservoirs, sewage works and pumping sta[illegible]ns. [illegible]ily rain g[illegible]es are normally read just once per day at 0900 GMT, the record[illegible] valu[illegible]eing a s[illegible]gle measurement of the rainfall of the pre[illegible]24 hours. T[illegible]onver[illegible]infall in millimetres to inches, multiply by 25.4.

Intensity of rain

Rain [illegible]to rain sh[illegible]rs) falls from dynamically produced stratiform (layere[illegible]cloud [illegible]ratus and [illegible]mbostratus in association with frontal zones. Slight rain is ra[illegible] of low i[illegible]hich usually consists of scattered large rain drops, or more nu[illegible]ou[illegible]maller rain drops. The rate of accumulation in a rain gauge is less than 0.5m[illegible] hour. Moderate rain is rain falling fast enough to form puddles quickly, to m[illegible]e down pipes flow freely and to give some spray over hard surfaces. Th[illegible]e of a[illegible]mulation in a rain gauge is between 0.5mm and 4.0mm per hour. Heavy [illegible] is s[illegible]ficiently intense to produce a roaring noise on roofs, forms a misty spray of[illegible]e rain droplets by splashing on road surfaces etc. and accumulates in a rain ga[illegible] at a rate greater than 4.0mm per hour. Moderate and heavy rain is norm[illegible] associated with layered cloud of great vertical depth, normally in [illegible]ciation with frontal zones, or troughs of low pressure. Drizzle is precipitation where the rain droplet size is very small - true drizzle droplets does not make a splash, or circular waves in a puddle. Drizzle is normally associated with very low cloud of the type stratus, and is often experienced in fog, or hill fog (cloud enveloping high ground). Freezing rain/drizzle is liquid water drops, with an air temperature below the zero Celsius mark (super-cooled water), which freeze on

impact with a ground surface whose temperature is also below the zero Celsius mark. This form of precipitation produces a particularly hazardous surface for foot and wheeled traffic. The ground effects of rain on a surface are determined by its rate of impact. In general terms, isolated periods of rain giving a 'trace' or 0.1mm of rainfall would do little more than dampen the ground, whereas 0.2mm falling in less than an hour would wet the ground, but without any puddle formation. Puddles will form only slowly. Small puddles would form on some previously dry metalled surfaces (tarmac/concrete) if 0.5mm falls in a relatively short period of say, one hour. Clearly, the size of puddles at any one location/time is, in part, a product of local natural/artificial drainage characteristics. The above criteria based on the ground effects of rainfall amounts are an approximate guide. The state of ground will depend on the intensity of rainfall and the rate of evaporation. Evaporation is very low in winter but averages about 3mm per day in summer. Rainfall can also be described as continuous (rainfalls of one hour or more without a break), or intermittent (a period of less than one hour, or a longer period of rainfall with noticeable breaks). Intermittent rain should not be confused with showers (the cloud type from which the precipitation is different). With respect to the classification for showers, which are associated with convective cloud, are often of short duration and are characterised by rapid fluctuations of intensity. As a rule, showers are regarded as slight if the rate of accumulation is <2.0mm/hr, moderate 2.0 to 10.0mm/hr, heavy 10.0 to 50.0mm/hr and violent >50.0mm/hr.

Rainfall equivalent

1mm of rain measured in a standard rain gauge is the equivalent of 1mm depth over an area of 1 square metre. 1mm. of snow is very roughly equal to 1mm. of rain. The range is from about 5 to 12 mm. of snow by the equivalent of rainfall, depending on the water content of the snow.

Rainfall radar

The methods of collecting rainfall data from rainfall stations are explained in sections 7.5 and 7.6; however, this section will explain rainfall accumulation from rainfall radar. Rainfall Radar (RAdio Detection And Ranging) is an echo-sounding system which uses the same aerial for transmitting a signal and receiving the returned echo. Short pulses of electro-magnetic waves are transmitted in a narrow beam for a short time (typically 2 microseconds). When the beam hits a suitable target, some of the energy is reflected back to the radar, which ‘listens’ out for it for a much longer period (3300 microseconds in the case of Met Office radars) before transmitting a new pulse. The distance of the target from the transmitter can be worked out from the time taken by a pulse to travel there and back. Corrections must be made to the raw data collected, including amendments for attenuation by intervening rain and range, elimination of ground clutter and the conversion of radar reflectivity to rainfall rate.

Each radar completes a series of scans about a vertical axis between four and eight low-elevation angles every 5 minutes (typically between 0.5 and 4.0 degrees, depending on the height of surrounding hills). Each scan gives good, quantitative data that shows detailed distribution of precipitation intensities (1 and 2 km resolutions) out to a range of about 75 km and useful qualitative data that provides a good overall picture of the extent of precipitation at a national/regional scale (5 km resolution) to 255km.

Disadvantages of rainfall radar:

The radar rainfall display may not fully represent the rainfall observed at the ground due to:

- Permanent echoes (occultation) caused by hills or surface obstacles.
- Spurious echoes caused by ships, aircraft, sea waves, chaff in use on military exercises, technical problems or interference from other radars.
- Radar beam above the cloud at long ranges- difficulties in detecting low-level rain clouds.
- Evaporation of rainfall at lower levels beneath the beam giving an over-estimate of the actual rainfall.
- Orographic enhancement of rainfall at low levels- light precipitation generated in layers of medium-level cloud can increase in intensity by sweeping up other small droplets as it falls through moist, cloudy layers at low levels.
- Bright Band Radar echoes from both raindrops and snowflakes are calibrated to give correct intensities on the rainfall display. However, at the level where the temperature is just above melting snowflakes with large, reflective surfaces give strong echoes. This produces a false band of heavier rain, or bright band, on the radar picture.
- Anomalous propagation (anaprop) - radar beams travel in straight lines through a uniform medium but will be refracted when passing through air of varying density. When a low-level temperature inversion exists, the radar beam is bent downwards, and strong echoes are returned from the ground, in a manner akin to the formation of mirages.

Advantages of rainfall radar:

- Detailed, instantaneous and integrated rainfall rates
- Areal rainfall estimates over a wide area
- Information in near-real time
- Information in remote land areas and over adjacent seas
- Location of frontal and convective (shower) precipitation
- Monitoring movement and development of precipitation areas
- Short-range forecasts made by extrapolation
- Data can be assimilated into numerical weather prediction models

Temperature

To convert temperatures in Celsius (°C) to Fahrenheit (°F), multiply by 9, divide by 5 and then add 32. The main problem in measuring air temperature is shielding thermometers from radiation, mainly short-wave radiation from the sun but also long wave radiation from the ground. Mainly, because of radiation, the air (dry bulb) temperature varies markedly with height above the ground and the type of surface. Thermometers also need to be kept dry as evaporation produces cooling. The solutions to these problems are resolved by recording the temperature of the air (recorded in degrees and tenths, Celsius) by housing the thermometers in the shade, at a height of 1.25 metres above the ground (normally over short grass, except in a few cities where roof top sites are used) in a louvered white box called a Stevenson Screen. The Stevenson Screen protects the thermometers from radiation and precipitation while the louvres permit ventilation. Air temperature values below zero degrees Celsius are preceded by a minus sign, while readings are made at each (notional) clock hour. In most modern-day ground based meteorological stations, the thermometers are of electrical resistance whereas in older ground based meteorological stations they are in the form of liquid-in-glass. Different thermometers are used for recording the maximum and minimum temperature. The highest and lowest air temperature recorded during the previous 24-hour period finalises at 0900 GMT. The wet bulb temperature records the temperature of a wet surface by means of a piece of muslin wrapped around the bulb of a thermometer and kept moist by capillary action from a reservoir of distilled water. The wet bulb thermometer indicates the 'temperature of evaporation' which is, in normal circumstances, lower than the air (dry bulb) temperature. The difference between the dry bulb and wet bulb temperature is known as the wet bulb depression. From the dry and wet bulb readings, relative humidity and vapour pressure can be obtained. The maximum, minimum and wet bulb thermometers are all housed in the Stevenson Screen as mentioned above. The dew point is the temperature to which air must be cooled before it becomes saturated with water vapour. It is so called because it is also the temperature to which a surface must be cooled before dew will be deposited. With reference to thermometers housed outside the Stevenson screen, the grass minimum temperature is recoded by a thermometer exposed to the air one or two inches above the ground. The bulb is in contact with the tips of the grass blades and refers to the period ending at 0900 GMT on the date of entry. The concrete minimum temperature, like the grass minimum temperature, is recorded by a thermometer, but in this instance, the bulb is positioned in the centre of and just touching the slab and again refers to the period ending at 0900 GMT on the date of entry. Finally, soil temperatures are read at 0900 GMT in the morning at selected weather stations. Bent stem thermometers record the soil temperature at 5cm, 10cm and 20cm under a bare soil surface.

Sun

The total amount of bright sunshine (hours and tenths) recorded on the date of entry. Measurement of the duration of sunshine refers to so-called 'bright' sunshine. Since different meteorological instruments differ in their response characteristics to solar radiation, this term has lacked precise definition. However, The World Meteorological Organisation decided in 1962 to adopt the Campbell-Stokes Recorder, as used in the British Isles, as the standard meteorological instrument for recording sunshine amount.

Total cloud

Total cloud amounts are estimated as the fraction, in eighths (oktas), of the sky covered by cloud. At manned ground based meteorological stations, this is assessed by human observers. Some ground based automatic meteorological stations make this assessment from cloud recording equipment.

State of ground

At manned ground based meteorological stations the state of ground refers to a bare patch of soil about 2m square and described accordingly. The state of ground includes descriptions such as moist, waterlogged, frozen, glazed, sand, ice, snow or dust covered.

Snow

Snow is much more difficult to measure than rain because the snowflakes blow around, rather than into a rain gauge. The snow that does enter the gauge blocks it and prevents the normal operation of the rain gauge. Nevertheless, the aim is to record the amount of water substance that falls as snow. At manned ground based meteorological stations this is achieved by melting the snow and recording the amount of water 'in'. Automatic rain gauges do not work well at temperatures below freezing point. Solid precipitation that falls collects in the rain gauge and no precipitation is registered. When the temperature rises above freezing, the snow melts and the rain gauge starts registering, even though the current weather may be dry. Daily rainfall amounts are quality controlled to overcome this deficiency and estimates of the correct daily rainfall are made. For hourly rainfall, it is more likely that original and erroneous data remain on the computer archive. There is a close relationship between the intensity of snowfall and visibility. Thus, if it is known that poor visibility is due to falling snow, the intensity of the precipitation can be inferred from the following table.

Visibility	Description of snowfall intensity	Equivalent rainfall intensity
5km	Slight snow	0.2mm/hr
2km	Slight /moderate snow	0.5mm/hr
1km	Moderate snow	1.0mm/hr
250m	Moderate/heavy snow	4.0mm/hr
110m	Heavy snow	10.0mm/hr

Dry snowflakes result in visibilities only about half of those given above. Visibility in wet snow is somewhat better, as wet snowflakes collapse to a smaller volume and become translucent. Blowing snow (most likely when the snow is dry and powdery) gives very low visibilities.

Snow depth

At manned ground based meteorological stations snow depth is measured with a ruler at three different locations and the average then taken. The area chosen for these measurements should be as close as possible to the rain gauge and not affected by drifting or scoured by the wind. Some automatic ground based meteorological stations measure snow depth by an optical technique.

Wind

Wind direction is measured in degrees from north (360 degrees of a circle) and relates to the direction from which the wind is blowing from. The quoted figures represent the wind direction averaged over the hour ending at the time of entry. A direction quoted as 360 degrees represents a wind from due north (a northerly wind); 090 degrees is from due east (an easterly wind) etc. Wind speeds are recorded in knots (1 knot = 1.1515 mph), and they refer to the average speed (which includes all gusts and all lulls) during the hour ending at the time of entry. The mean wind speed refers to the highest mean wind at 10m above ground in an open rural situation measured in the 10 minutes immediately preceding each hour. The maximum gust speed is also recorded in knots; the highest value (even if only of momentary duration) attained during the hour ending at the time of entry. The maximum wind gust refers to the highest 3-5 second gust at 10m above ground level by the anemometer. Gale force gusts are gusts >=39 mph. A gust is a rapid, but momentary increase in the speed of the wind, relative to the mean wind speed at the time. Equally, a lull is a momentary decrease below the mean wind speed. Wind speed generally increases with height according to a power law expression, i.e. Speed at height H = speed recorded at 10 metres x Pow ((Height H in metres/10 metres) p) where the power p takes a value between 0.067 and 0.29 depending upon local terrain roughness and whether it is mean or gust speed under consideration. Beaufort Force = Pow(Pow((“Wind Speed (mph)” / 1.87), 2), 1/3).

Beaufort Forces apply only to mean wind speeds and must not be used in reference to gusts.

Glossary of Meteorological Terms

Astronomical dawn and dusk - Morning astronomical twilight begins (astronomical dawn) and evening astronomical twilight ends (astronomical dusk) when the geometric centre of the Sun reaches 18° below the horizon. In the period of astronomical twilight (when the sun is between 12° and 18° below the horizon), away from urban light pollution, moonlight, auroras and other sources of light, the sky is darker enough for nearly all astronomical observations. Astronomers can easily make observations of point sources such as stars both during and after astronomical twilight in the evening and both before and during astronomical twilight in the morning. Some critical observations; however, such as viewing nebulae and galaxies require observations beyond the limit of astronomical twilight. In theory, the faintest stars detectable by the naked eye (those of approximately the sixth magnitude) will become visible in the evening at astronomical dusk and become invisible at astronomical dawn. In certain places, astronomical twilight may be almost indistinguishable from night. In the evening, even when astronomical twilight has yet to end and in the morning when astronomical twilight has already begun, most casual observers would consider the entire sky fully dark.

Black ice - is a thin coating of ice on a ground surface, formed when moisture from either natural or unnatural sources, for example, rain, freezing rain or drizzle, surface run-off, etc. becomes present on exposed objects with a surface temperature below or at freezing (0ºC). It is near transparent due to the fact it is only a thin accumulation of ice, making it much harder to see in comparison to snow, frozen slush or thicker ice layers. The 'black' term comes from the fact that when the ice or 'glaze' forms on a road surface, the black tarmac underneath can be seen clearly through it presenting a distinct risk of pedestrians and automobiles.

Civil twilight - is defined to begin at sunset and ends when the geometric centre of the sun is 6° below the horizon. This is the limit at which twilight illumination is enough, under good weather conditions, for terrestrial objects to be clearly distinguished. At the end of evening civil twilight, the horizon is clearly defined, and the brightest stars are visible under good atmospheric conditions in the absence of moonlight or other illumination.

Cloud cover - The total cloud amount or cloud cover is the fraction of the celestial dome covered by all clouds visible. The assessment of the total amount of cloud, therefore, consists in the weather observer estimating how much of the total apparent area of the sky is covered with cloud. The international unit for reporting the cloud amount is the 'okta' or eighth of the sky, with 0 oktas equating to a clear sky and 8 oktas equating to an overcast sky.

Cold Front - A frontal system whose movement is such that the colder air mass is replacing the warmer air mass. The passage of the cold front is marked at the surface by a rise in pressure, a fall of temperature and dew-point and a veer of wind direction.

Condensation - In meteorology, the formation of liquid water from water vapour. Since the capacity of air to hold water in the form of vapour decreases with temperature, cooling of air is the normal method by which first saturation, then condensation, is produced. Such cooling is affected by three main processes:
(i) the expansion of ascending air,
(ii) mixing with air at lower temperature,
(iii) contact with earth's surface at lower temperature.
The water vapour condenses as cloud in (i), as fog or cloud in (ii), and as dew or hoar frost in (iii).

Dew - Condensation of water vapour on a surface whose temperature is reduced by radiational cooling to below the dew-point of the air in contact with it. Of the two recognized processes of dew formation the more common occurs in conditions of calm (wind at two metres height less than one knot) when water vapour diffuses from the soil upwards to the exposed cooling surface in contact with it (e.g. grass) and there condenses. The second of the processes is one of 'dewfall' when, in conditions of light wind, downward turbulent transfer of water vapour from the atmosphere to the cooled surface occurs.

Dew-Point - The dew-point of a moist air sample is that temperature to which the air must be cooled in order that it shall be saturated with respect to water at its existing pressure and humidity mixing ratio. Dew-point may be measured indirectly from wet- and dry-bulb temperature readings with the aid of humidity tables, or directly with a 'dew-point hygrometer'.

Freezing drizzle, freezing fog, freezing rain - Supercooled water drops of drizzle (or fog or rain) which freeze on impact with the ground to form glazed frost or, in the case of smaller droplets which comprise of fog to form rime.

Freezing point - The constant temperature at which the solid and liquid forms of a given pure substance are in equilibrium at standard atmospheric pressure. For pure-water substance the temperature is 0°C and is termed the 'ice-point' or 'freezing-point'. In practice, a cooling liquid may not freeze at the freezing-point due to pressure variation from standard atmospheric pressure, or the presence of impurities, or the phenomenon supercooling.

Frost - Frost occurs when the temperature of the air in contact with the ground or at screen level (about four feet), is below the freezing-point of water ('ground frost' or 'air frost', respectively). The term is also used of the icy deposits which may form on the ground and on objects in such temperature conditions.

Frost Hollow - A local hollow-shaped region in which, in suitable conditions, cold air accumulates by night due to a katabatic air flow (see katabatic wind definition). Such regions are subject to a greater incidence of frosts and to more severe frosts, than are the surrounding areas of non-concave shape.

Funnel cloud - Is a funnel-shaped cloud of condensed water droplets, associated with a rotating column of wind and extending from the base of a cloud (usually a cumulonimbus or towering cumulus cloud) but not reaching the ground or water surface. A funnel cloud is usually visible as a cone-shaped or needle like protuberance from the main cloud base. Funnel clouds form most frequently in association with supercell thunderstorms. If a funnel cloud touches the ground it becomes a tornado. Most tornadoes begin as funnel clouds, but many funnel clouds do not make ground contact and so do not become tornadoes.

Glazed Frost - A coat of ice, generally smooth and clear, formed by the falling of rain or drizzle (or sleet) on a surface whose temperature is below freezing-point: It may also form due to a sudden onset of warm, moist air following a severe frost, by the condensation and freezing of water on surfaces at temperatures still below freezing-point.

Grass Minimum Temperature - The minimum temperature indicated by a thermometer freely exposed in an open situation at night with its bulb in contact with the tips on the grass leaves on an area covered with short turf.

Ground Frost - The term forecast signifies a grass minimum temperature below 0°C (32°F).

Gust front - is a leading edge/boundary (squall line) that separates a cold downdraft (outflow winds that spread outwards from a thunderstorm)) of an organised line of thunderstorms from warm, humid surface (environmental) air. Its passage at the surface resembles the passage of a cold front. This squall line is marked by upward motion along it and downward motion behind it. It is normally followed by a surge of gusty winds at or near the ground. A gust front is often associated with an atmospheric pressure rise, wind shift, an air temperature drop and sometime heavy precipitation.

Hoar/Glass Frost - This is a series of interlocked ice crystals that develop on surfaces during cold, typically clear nights where the exposed surface is chilled below the dew point of the surrounding air and the surface itself is colder than 0ºC. Similarly, where air cooled by ground-level radiation loss travels downhill to form pockets of cold air in depressions, valleys and frost hollows, hoar frost can form even where the air temperature above ground is above freezing.

Humidity - This is the term used to describe the amount of water vapour in the air and can indicate the likelihood of precipitation, dew or fog. A device used to measure humidity is called a hygrometer. At an official weather station, humidity is recorded by a wet bulb and dry bulb thermometer. The difference between the two temperature readings allows the observer to calculate the dew point and the humidity in a percentage form.

Katabatic wind - On a 'radiation night' of clear skies and low-pressure gradient, terrestrial radiation from the earth's surface causes a layer of cold air to form near the ground, with an associated inversion of temperature. If the ground is sloping, the air close to the ground is colder than air at the same level but at some greater horizontal distance. Downslope gravitational flow of the colder, denser air beneath the warmer, lighter air results and comprises the 'katabatic wind'.

Nautical dawn and dusk - Morning nautical twilight begins (nautical dawn) and evening nautical twilight ends (nautical dusk) when the geometric centre of the sun reaches 12° below the horizon. Nautical twilight (when the sun is between 6° and 12° below the horizon), artificial lighting must be used to see terrestrial objects clearly. Before nautical dawn and after nautical dusk, sailors cannot navigate via the horizon at sea. Under good atmospheric conditions with the absence of other illumination, during nautical twilight, the human eye may distinguish general outlines of ground objects but cannot participate in detailed outdoor operations.

Occlusion - A front develops during the later stages of the life-cycle of a frontal depression. It term arises from the associated occluding (shutting off) of the warm air from the earth's surface.

Okta - equal to area of one eighth of the sky, used in specifying cloud amount.

Sensible and Latent Heat (Hidden Heat) - In meteorology, latent heat flux is the flux of heat from the earth's surface to the atmosphere that is associated with evaporation or transpiration of water at the surface and subsequent condensation of water vapor in the troposphere. It is an important component of Earth's surface energy budget.

Sleet - precipitation of snow and rain together or of snow melting as it falls.

Squall - a sudden, sharp increase in wind speed which is usually associated with active weather, such as rain showers, thunderstorms, or heavy snow. Squalls refer to the increase in the sustained winds over a short time interval, as there may be higher gusts during a squall event. They usually occur in a region of strong mid-level height falls, mid-level tropospheric cooling, which force strong localised upward motions at the leading edge of the region of cooling, which then enhances local downward motions just in its wake.

Straight-line winds - are very strong winds that can produce damage, demonstrating a lack of a rotational damage pattern. Such rotational damage patterns are associated with cyclonic storms including tornadoes and tropical cyclones. Straight-line winds are common with the gust front of a thunderstorm or originate with a downburst from a thunderstorm. These events can cause considerable damage, even in the absence of a tornado. The winds can reach 80mph (130km/h) or more and can last for periods of twenty minutes or longer.

Synoptic Meteorological Charts - This is a weather chart that reflects the state of the atmosphere over a geographical area at a certain time based on information gathered from weather stations at surface level. The chart is created by plotting or tracing the values of relevant quantities (including sea level pressure, temperature, etc.) and show the presence or potential development of weather fronts and systems.

Thaw - The transition by melting from snow or ice to water. This term is especially used to indicate the end of a spell of frost, which in the British Isles in winter is generally associated with the displacement of a stagnant or continental air mass by one of maritime origin.

Tornado - is a violently rotating column of air that is in contact with both the surface of the earth and a cumulonimbus cloud. Tornadoes come in many shapes and sizes, but they are typically in the form of a visible condensation funnel, whose narrow end touches the earth and is often encircled by a cloud of debris and dust. Most tornadoes have wind speeds less than 110 mph (177km/h), are about 250 feet (76m) across, and travel a few miles before dissipating.

Trough - A non-frontal line on a synoptic chart usually associated with an organised band of cloud, usually showery weather.

Visibility - Meteorological visibility is defined as the greatest distance at which a black object of suitable distance can be seen and recognised against the horizon sky. The simplest determinations of daylight visibility have, for many years, been deduced by how well a series of objects or lights of known distance can be seen from a certain point of a meteorological station. The estimated distance is then noted in the records. More recently; however, automated weather systems including a “forward scatter sensor” have been used, particularly at airports. This instrument produces pulsed flashes of light, some of which is scattered at an angle towards a photocell detector. Visibility is then estimated from the intensity of the scattered light. The sensors report a visibility based on one-minute samples averaged over the past ten minutes leading up to each observation.

Warm Front - A frontal system whose movement is such that the warmer air mass is replacing a colder air mass. The passage of a warm front is marked at the

surface by a rise in temperature and dew-point, a veer of wind direction and a steadying of pressure.