WeatherNet Limited | Suite 2, 65 Seamoor Road | Westbourne | Bournemouth | BH4 9AE | Phone +44 1202 296396

27th January 2023

XXXXX XXXXX
XXXXXXX
XXXXX XXX XX XXX
X XXXXXX XXXXXX
XXXXXXX
XX XXX

Dear XXXXX,

Incident

Location: Mountcastle Crescent, Edinburgh (EH8 7SY)
Date: 18th December 2019
Time: 04:00
Your Reference: XX/XXX.X.XX

Please find enclosed a legal meteorological report as 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 rainfall radar imagery. This meteorological report complies with civil and criminal procedures. This meteorological report based on meteorological facts 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 I can be of further assistance in this or in any other legal case in the future.

Yours sincerely,

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

Encl.: Legal weather report with respect to the legal case at Mountcastle Crescent, Edinburgh (EH8 7SY) on 18th December 2019

Legal Meteorological Report

Your Reference: XX/XXX.X.XX
Creation Date: 5th January 2023
Client: XXXXX XXXXXX XXX XXXXX

Prepared for and instructed by

XXXXX XXXXX
XXXXXXX
XXXXX XXX XX XXX
X XXXXXX XXXXXX
XXXXXXX
XX XXX

Telephone: XXXX XXX XXXX
Direct Telephone: XXXXX XXXXXX
Email: XXXXX.XXXXX@XXXXXXX.XXX

Author

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

Suite 2, 65 Seamoor Road, Westbourne, Bournemouth, BH4 9AE

Meteorological report for postcode EH8 7SY for the 18th December 2019

Contents

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 Meteorological 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 facts as to the probable meteorological conditions in the above area on the date and time indicated. This meteorological report complies with civil and criminal procedures 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 for	XXXXX XXX XX XXX
1.4	Your reference	XX/XXX.X.XX
1.5	Place of incident	Mountcastle Crescent, Edinburgh (EH8 7SY)
1.6	Date of incident	18th December 2019
1.7	Time of incident	04:00

1.8 Summary of my 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-informed estimate that during the incident time across the postcode EH8 7SY would have been as follows. There were a light south-westerly winds (Beaufort Scale 1) with gusts ~10mph. Air temperatures were ~0 to -1°C, while the weather was dry with partially cloudy skies with clear periods. The state of the ground would have been frozen as the ground and the frost had formed across the incident area since the previous evening due to light winds and high humidity levels which would have resulted in icy conditions up until and including the incident time. No natural black ice would have present as no measurable precipitation had fallen during the 17th and in the early hours of the 18th.

Please note, however, a number of different factors that can also play a part in determining whether ice/frost 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 frictional heat dissipation from the tyres and braking). Traffic can also prevent/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 will 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/frost and on individual/council winter plans.

1.9 The parties involved

I have prepared this meteorological report for and on behalf of XXXXX XXX XX 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 as a statement of instructions

I have prepared this meteorological report for and on behalf of XXXXX XXX XX XXX, contained in their correspondence and instructions dated the 16th December 2022. The purpose of this meteorological report is to give an expert opinion based on the meteorological conditions for the probable meteorological conditions in the above area on the date and time indicated. The meteorological issues addressed (if available) included 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 Edinburgh Royal Botanic Gardens & Edinburgh Gogarbank
The nearest daily stations to the incident are Edinburgh Royal Botanic Gardens & Edinburgh Gogarbank

These hourly and daily meteorological/rainfall data (manned and automatic weather stations) are the best available in the close locality 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. Rainfall Radar data was available; however, was not requested to be included in this case.

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 on other meteorological sources, for example examining synoptic meteorological charts, lightning maps, and amateur meteorological stations (where available for the incident date). Based upon data analysis, a study of the general meteorological situation and aspects of meteorological theory, my conclusions, interpretation, interpolation, and opinion therefore are as follows based on the relevant data available to me within the given time frame to produce this report.

The 18th December 2019 at 00:00 GMT saw low pressure centred between Scotland and Norway and across Norway. Low pressure was also located to the west of Ireland and between Scotland and Iceland. An occluded front lay to the south-west of Ireland, while an occluded front also was located to the north of Scotland. A trough of showers lay across Scotland, while a fine trough of showers lay close to southern and south-eastern England.

The 18th December 2019 at 04:00 across the BH18 7SY area saw light south-westerly winds (Beaufort Scale 1). The highest gust that occurred within the incident area during that time was 7mph. Other meteorological factors occurring over the incident time included, air temperatures were ~0 to -1°C, while the weather was dry with partially cloudy skies with clear periods. The state of the ground would have been frozen, as a thaw and any frost had formed across the incident area since the previous evening due to light winds and high humidity levels which would have resulted in icy deposits to until and including the incident time. No natural black ice would have present as no measurable precipitation had fallen during the 17th and in the early hours of the 18th.

These meteorological readings presented above are based on real meteorological data recorded at nearby ground-based weather stations and 'synthetic observations such as numerically served data'. 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 time across the postcode EH8 7SY would have been as follows: Winds were a light south-westerly winds (Beaufort Scale 1) with gusts ~10mph. Air temperatures were ~0 to -1°C, while the weather was dry with partially cloudy skies with clear periods. The state of the ground would have been frozen, as a ground and air frost had formed across the incident area since the previous evening due to light winds and high humidity levels which would have resulted in icy deposits up until and including the incident time. No natural black ice would have present as no measurable precipitation had fallen during the 17th and in the early hours of the 18th.

Please note, however, a number of different factors that can also play a part in determining whether ice/frost 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 frictional heat dissipation from the tyres and braking). Traffic can also prevent/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 reverse 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 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 geography/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/frost 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 XXXXX XXX XX 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 XXXXX XXX XX XXX by whom I am instructed if, between the date of my meteorological report and the trial, there is any 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 of 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, without forming an independent view, included, or excluded anything which has been suggested to me by others, including my instructing lawyer XXXXX XXX XX XXX.
10. I will notify XXXXX XXX XX XXX immediately and confirm in writing if, for any reason, my existing 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.
    - 11.3 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 that 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. I understand that proceedings for contempt of court may be brought against anyone who makes, or causes to be made, a false statement in a document verified by a statement of truth without an honest belief in its truth.

7. Date and signature

Date: 27th January 2023

To: XXXXX XXXXX
XXXXXXX
XXXX XXX XX XXX
X XXX XX XXXX
XXXXXX
XX XXX

Sign

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

WeatherNet

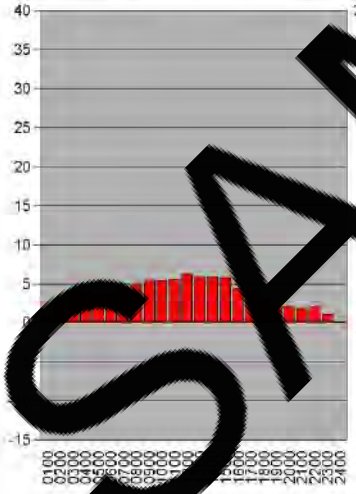
Weather at Edinburgh, Royal Botanic Garden No 2[1]

Tuesday 17 December 2019

See key for explanatory notes

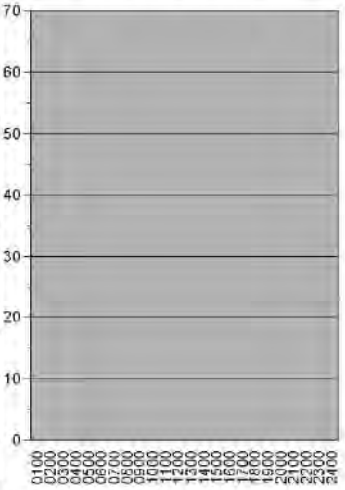
GMT	Air Temp	Humidity	Rain	Visibility	Sun	Cloud Cover	Wind From	Mean Wind	Max Gust	Weather
0100	0.7°C	93.0%	0.0mm							No data
0200	2.9°C	87.3%	0.0mm							No data
0300	4.0°C	82.5%	0.0mm							No data
0400	4.1°C	80.8%	0.0mm							No data
0500	3.6°C	84.3%	0.0mm							No data
0600	3.9°C	84.9%	0.0mm							No data
0700	4.6°C	82.0%	0.0mm							No data
0800	4.9°C	80.9%	0.0mm							No data
0900	5.6°C	79.3%	0.0mm							No data
1000	5.5°C	79.3%	0.0mm							No data
1100	5.7°C	78.2%	0.0mm							No data
1200	6.4°C	78.9%	0.0mm							No data
1300	5.9°C	87.6%	0.0mm							No data
1400	6.0°C	79.9%	0.0mm							No data
1500	5.8°C	79.9%	0.0mm							No data
1600	4.5°C	82.6%	0.0mm							No data
1700	4.3°C	82.6%	0.0mm							No data
1800	3.1°C	88.6%	0.0mm							No data
1900	2.1°C	91.8%	0.0mm							No data
2000	2.1°C	93.8%	0.0mm							No data
2100	1.8°C	92.4%	0.0mm							No data
2200	2.1°C	91.8%	0.0mm							No data
2300	1.1°C	93.0%	0.0mm							No data
2400	0.1°C	95.0%	0.0mm							No data
Totals			0.0mm							

Air Temperature (°C)



Rainfall (mm)

Mean Wind and Gust (kt)



[1] Edinburgh, Royal Botanic Garden No 2 (26m ASL) is 3.4 miles W of EH8 7SY (20m ASL)

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Weather Claims Experts

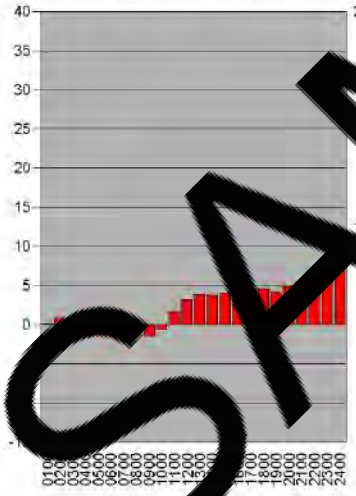
WeatherNet

Weather at Edinburgh, Royal Botanic Garden No 2'
Wednesday 18 December 2019

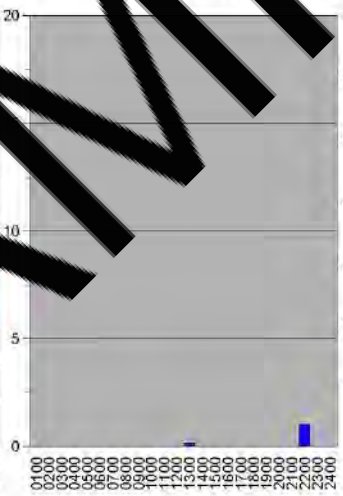
See key for explanatory notes

GMT	Air Temp	Humidity	Rain	Visibility	Sun	Cloud Cover	Wind From	Mean Wind	Max Gust	Weather
0100	0.2°C	97.8%	0.0mm							No data
0200	0.8°C	97.9%	0.0mm							No data
0300	-0.5°C	96.4%	0.0mm							No data
0400	-1.1°C	97.8%	0.0mm							No data
0500	-1.2°C	97.8%	0.0mm							No data
0600	-1.3°C	98.5%	0.0mm							No data
0700	-1.9°C	97.8%	0.0mm							No data
0800	-0.9°C	99.3%	0.0mm							No data
0900	-1.5°C	98.5%	0.0mm							No data
1000	-0.6°C	99.3%	0.0mm							No data
1100	1.7°C	99.3%	0.0mm							No data
1200	3.2°C	92.5%	0.0mm							No data
1300	3.9°C	85.5%	0.2mm							No data
1400	3.8°C	83.1%	0.0mm							No data
1500	4.1°C	79.6%	0.0mm							No data
1600	4.3°C	80.2%	0.0mm							No data
1700	4.6°C	82.6%	0.0mm							No data
1800	4.6°C	82.0%	0.0mm							No data
1900	4.2°C	83.2%	0.0mm							No data
2000	4.9°C	85.0%	0.0mm							No data
2100	5.6°C	83.9%	0.0mm							No data
2200	6.0°C	89.5%	1.0mm							No data
2300	7.1°C	84.1%	0.0mm							No data
2400	7.4°C	85.3%	0.0mm							No data
Totals			1.2mm							

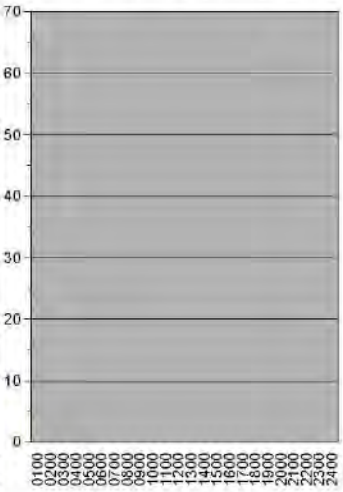
Air Temperature (°C)



Rainfall (mm)



Mean Wind and Gust (kt)



¹ Edinburgh, Royal Botanic Garden No 2 (26m ASL) is 3.4 miles W of EH8 7SY (20m ASL)

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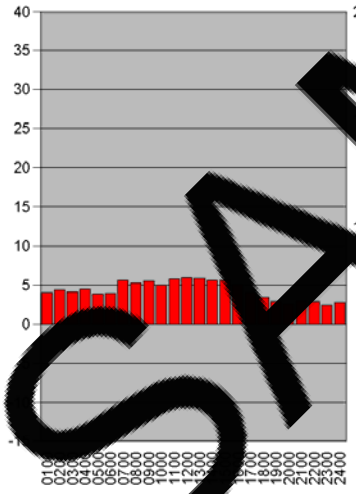
Weather at Edinburgh, Gogarbank[1]

Tuesday 17 December 2019

See key for explanatory notes

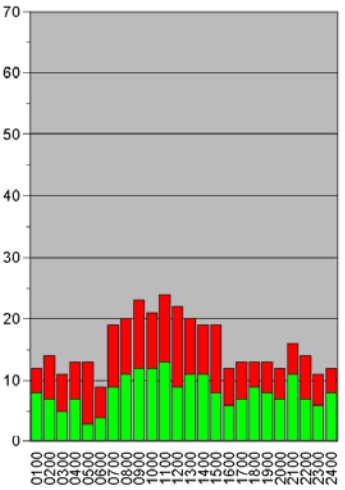
GMT	Air Temp	Humidity	Rain	Visibility	Sun	Cloud Cover	Wind From	Mean Wind	Max Gust	Weather
0100	4.1°C	80.2%	0.0mm	35km	0hr	37.5%	210°	8kt	12kt	None
0200	4.4°C	79.7%	0.0mm	40km	0hr	62.5%	210°	7kt	14kt	None
0300	4.2°C	80.8%	0.05mm	50km	0hr	12.5%	200°	5kt	11kt	Rain
0400	4.5°C	80.9%	0.0mm	50km	0hr	0%	170°	7kt	13kt	None
0500	3.9°C	83.1%	0.0mm	50km	0hr	50%	190°	3kt	13kt	None
0600	4.0°C	84.3%	0.0mm	40km	0hr	62.5%	200°	4kt	9kt	None
0700	5.7°C	78.7%	0.0mm	35km	0hr	75%	210°	9kt	19kt	No
0800	5.3°C	79.8%	0.0mm	50km	0hr	62.5%	210°	11kt	20kt	
0900	5.6°C	81.0%	0.0mm	50km	0hr	87.5%	210°	12kt	23	one
1000	5.0°C	82.1%	0.0mm	50km	0hr	0%	210°	12kt	2	None
1100	5.8°C	78.8%	0.0mm	40km	0.3hr	0%	220°	13kt	24kt	e
1200	6.0°C	82.8%	0.0mm	27km	0.7hr	75%	230°	9kt	22kt	
1300	5.9°C	86.4%	0.05mm	50km	0hr	87.5%	240°	11kt	20kt	Rai
1400	5.7°C	82.2%	0.0mm	50km	0.1hr	25%	250°	11kt	19kt	None
1500	5.7°C	80.4%	0.0mm	50km	0.1hr	87.5%	260°	8kt	19kt	None
1600	5.1°C	81.5%	0.0mm	50km	0hr	87.5%	2	6kt	12kt	None
1700	4.1°C	83.1%	0.0mm	50km	0hr		250	7kt	13kt	None
1800	3.5°C	89.3%	0.0mm	50km	0hr	0%	240°	kt	13kt	None
1900	2.9°C	89.8%	0.0mm	50km	0hr	0%	240°		13kt	None
2000	2.7°C	88.5%	0.0mm	45km	0hr			7	12kt	None
2100	3.0°C	87.9%	0.0mm	50km	0hr	%	2	11kt	kt	No
2200	2.9°C	87.9%	0.0mm	50km	0hr	0%	23	7kt		
2300	2.5°C	87.9%	0.0mm	50km	0	0%	2	6kt	11	one
2400	2.8°C	92.5%	0.0mm	40km	0	0%		8kt	12kt	None
Totals			0.1mm		1.2hr					

Air Temperature (°C)



Rainfall (mm)

Mean Wind and Gust (kt)



[1] Edinburgh, Gogarbank (57m ASL) is 8.5 miles W of EH8 7SY (20m ASL)

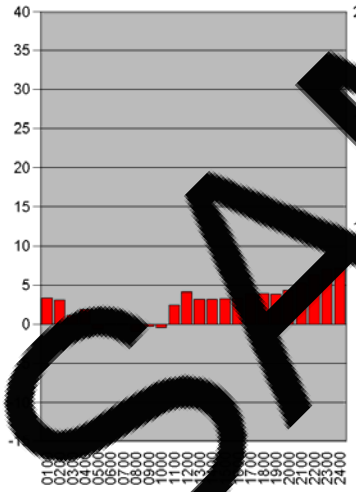
WeatherNet

Weather at Edinburgh, Gogarbank[1]
Wednesday 18 December 2019

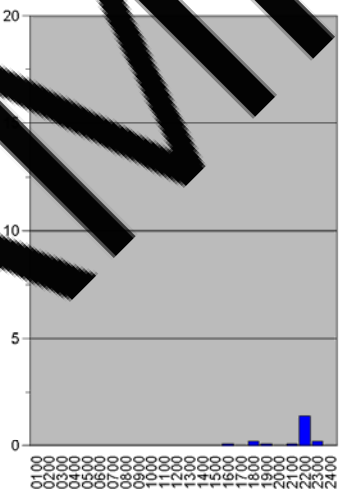
See key for explanatory notes

GMT	Air Temp	Humidity	Rain	Visibility	Sun	Cloud Cover	Wind From	Mean Wind	Max Gust	Weather
0100	3.4°C	91.2%	0.0mm	50km	0hr	0%	220°	7kt	13kt	None
0200	3.1°C	89.2%	0.0mm	50km	0hr	0%	220°	5kt	11kt	None
0300	1.2°C	88.4%	0.0mm	30km	0hr	0%	250°	2kt	8kt	None
0400	1.9°C	89.8%	0.0mm	50km	0hr	0%	250°	3kt	10kt	None
0500	-0.6°C	94.3%	0.0mm	25km	0hr	37.5%	090°	1kt	4kt	None
0600	0.1°C	98.6%	0.0mm	35km	0hr	0%	160°	3kt	5kt	None
0700	0.1°C	85.7%	0.0mm	28km	0hr	0%	250°	4kt	10kt	No
0800	-0.8°C	95.7%	0.0mm	29km	0hr	0%	060°	2kt	4kt	
0900	-0.2°C	95.0%	0.0mm	17km	0hr	0%	100°	2kt	7	one
1000	-0.4°C	95.0%	0.0mm	14km	0hr	0%	340°	2kt		None
1100	2.5°C	91.1%	0.0mm	19km	0.5hr	0%	090°	4kt	6kt	
1200	4.2°C	81.4%	0.0mm	30km	0.9hr	0%	110°	5kt	10kt	
1300	3.2°C	88.0%	0.0mm	18km	0.1hr	0%	070°	6kt	10kt	No
1400	3.2°C	87.3%	0.0mm	22km	0hr	25%	020°	2kt	8kt	None
1500	3.3°C	84.3%	0.0mm	45km	0hr	75%	070°	5kt	9kt	None
1600	3.4°C	84.3%	0.05mm	50km	0hr	87.5%	0	7kt	11kt	Rain
1700	4.0°C	83.1%	0.0mm	50km	0hr	100%	090	10kt	16kt	None
1800	4.0°C	86.2%	0.2mm	24km	0hr	100%	090°	kt	17kt	Slight rain showers
1900	3.9°C	85.5%	0.05mm	19km	0hr	87.5%	100°		20kt	Rain
2000	4.3°C	87.4%	0.0mm	28km	0hr	87	10		17kt	None
2100	5.3°C	86.9%	0.05mm	30km	0hr	%	0	7kt	kt	Sli ain showers
2200	6.4°C	85.2%	1.4mm	50km	0hr	7.5%	11	11kt		
2300	7.1°C	84.1%	0.2mm	50km	0	75%	12	13kt	22	ain
2400	7.2°C	86.5%	0.0mm	50km	0	87.5%		9kt	20kt	None
Totals			1.95mm		1.5hr					

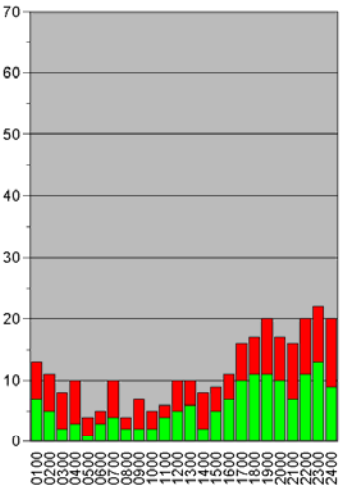
Air Temperature (°C)



Rainfall (mm)



Mean Wind and Gust (kt)



[1] Edinburgh, Gogarbank (57m ASL) is 8.5 miles W of EH8 7SY (20m ASL)

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Hourly Station Data - Key

WeatherNet

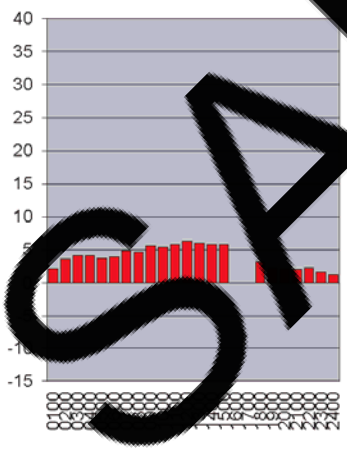
UKPP Weather Report for EH8 7SY

Tuesday 17 December 2019

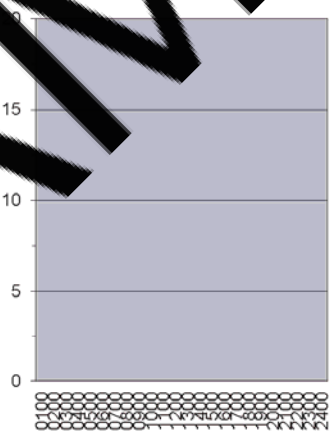
See key for explanatory notes

GMT	Air Temp	Humidity	Rain	Visibility	Cloud Cover	Wind From	Mean Wind	Max Gust	Weather Notes
0100	2.2°C	86.9%	0.0mm	32,506m	25.0%	178°	4kt	16kt	
0200	3.6°C	83.8%	0.0mm	34,776m	46.2%	205°	6kt	21kt	
0300	4.2°C	81.5%	0.0mm	37,318m	12.5%	199°	4kt	22kt	
0400	4.2°C	80.5%	0.0mm	35,438m	23.8%	153°	11kt	21kt	
0500	3.7°C	83.6%	0.0mm	30,958m	53.8%	192°	4kt	19kt	
0600	4.0°C	84.0%	0.0mm	23,472m	67.5%	185°	7kt	21kt	
0700	4.9°C	80.9%	0.0mm	22,266m	55.0%	196°	8kt	17kt	Astron[illegible]al Dawn at 06[illegible]
0800	4.7°C	81.4%	0.0mm	20,314m	77.5%	189°	11kt	24kt	Na[illegible] Dawn at 070[illegible]l Dawn at 0750
0900	6.6°C	70.0%	0.0mm	22,202m	71.2%	194°	13kt	26kt	Sunrise [illegible]8
1000	5.4°C	80.2%	0.0mm	23,442m	12.5%	208°	12kt	21kt	
1100	5.8°C	78.2%	0.0mm	27,678m	12.5%	200°	10kt	18kt	
1200	6.3°C	79.8%	0.0mm	27,368m	78.8%	231°	9kt	24kt	
1300	6.0°C	85.9%	0.0mm	17,376m	95.0%	244°	10[illegible]	20kt	Moon Set at 1224
1400	5.8°C	80.3%	0.0mm	16,516m	43.8%	249°	10kt	19kt	
1500	5.8°C	79.4%	0.0mm	14,432m	93.8%	260°	8kt	[illegible]kt	
1600									Sunset at 1538
1700									l Dusk at [illegible]
1800	3.2°C	88.2%	0.0mm	12,860m	0.0%	[illegible]5°	9[illegible]	20kt	[illegible]al D[illegible]at 1714. Astronomical Dus[illegible]9
1900	2.3°C	90.2%	0.0mm	13,388m	0[illegible]	252°	9[illegible]	19kt	
2000	2.2°C	90.8%	0.0mm	14,282m	0.0[illegible]	263°	[illegible]t	20kt	
2100	2.1°C	89.9%	0.0mm	19,214m	0.0%	[illegible]°	12kt	22kt	
2200	2.3°C	89.3%	0.0mm	19,420[illegible]	[illegible].0%	2[illegible]	9kt	20kt	Moon Rise at 2159
2300	1.7°C	90.0%	0.0mm	24,340m	[illegible]%	231	7kt	19kt	
2400	1.2°C	92.1%	0.0mm	21,810m	12[illegible]	247°	[illegible]kt	16kt	
Totals			0.0mm						

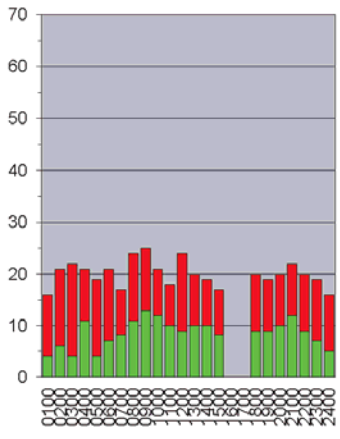
Air Temperature (°C)



Rainfall (mm)



Mean Wind & Max Gust (kt)



WeatherNet

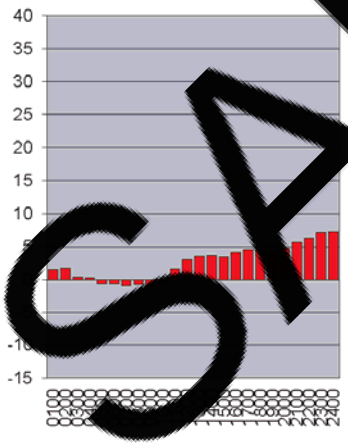
UKPP Weather Report for EH8 7SY

Wednesday 18 December 2019

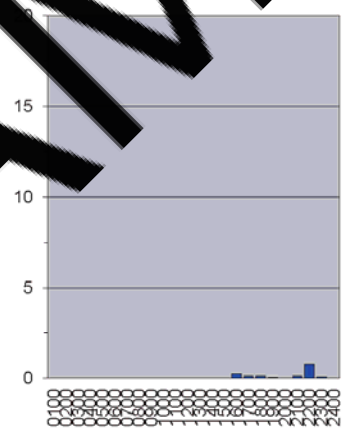
See key for explanatory notes

GMT	Air Temp	Humidity	Rain	Visibility	Cloud Cover	Wind From	Mean Wind	Max Gust	Weather Notes
0100	1.5°C	93.0%	0.0mm	22,290m	8.8%	279°	4kt	14kt	
0200	1.7°C	92.8%	0.0mm	17,714m	12.5%	159°	2kt	10kt	
0300	0.4°C	92.1%	0.0mm	17,090m	12.5%	227°	2kt	8kt	
0400	0.3°C	93.6%	0.0mm	14,440m	33.8%	212°	3kt	7kt	
0500	-0.6°C	95.0%	0.0mm	14,562m	58.8%	206°	2kt	11kt	Slight frost
0600	-0.6°C	97.2%	0.0mm	10,486m	18.8%	218°	2kt	9kt	Slight frost
0700	-0.9°C	98.5%	0.0mm	6,182m	12.5%	190°	2kt	9kt	Slight f Astronomical m at 061
0800	-0.7°C	97.1%	0.0mm	8,312m	12.5%	242°	1kt	6kt	Slight Nautical m at 0703 Civil Da 075
0900	-1.1°C	98.2%	0.0mm	6,020m	0.0%	168°	4kt	14kt	Slight frost at 0839
1000	-0.6°C	97.9%	0.0mm	5,938m	0.0%	151°	2kt	13kt	Slight frost
1100	1.6°C	95.8%	0.0mm	8,450m	96.2%	129°	5kt	11kt	
1200	3.1°C	89.0%	0.0mm	15,242m	100.0%	129°	8	12kt	
1300	3.6°C	86.5%	0.0mm	17,434m	100.0%	101°	7	12kt	Moon Set at 1243
1400	3.7°C	84.8%	0.0mm	20,708m	50.0%	102°	5kt	0kt	
1500	3.5°C	85.4%	0.0mm	23,582m	83.8%	086°	3kt		
1600	4.1°C	82.0%	0.2mm	12,138m	95.0%	1		13	nset at 153
1700	4.5°C	82.8%	0.1mm	5,150m	100.0%	2°	7	18kt	Dusk 26
1800	4.5°C	83.4%	0.1mm	3,988m	100.0	122°	13k	23kt	Na k at 1714
1900	4.2°C	84.1%	0.0mm	4,704m	95	126°	1	22kt	Astron ical Dusk at 1800
2000	4.8°C	85.9%	0.0mm	6,444m	96.2	120°		27kt	
2100	5.7°C	85.1%	0.1mm	12,660m	95.0%		9kt	21kt	
2200	6.3°C	87.1%	0.7mm	25,302m	0.0%	1	10kt	28kt	
2300	7.1°C	83.8%	0.1mm	26,772m	%	157	11kt	22kt	
2400	7.2°C	85.8%	0.0mm	20,824m	92	104°	kt	17kt	Moon Rise at 2326
Totals			1.3mm						

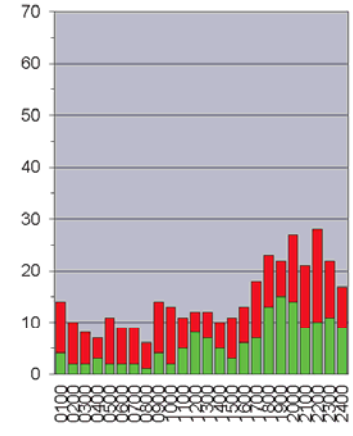
Air Temperature (°C)



Rainfall (mm)



Mean Wind & Max Gust (kt)



Hourly Remotely Sensed Data - Key

WeatherNet

Weather for 20km around EH8 7SY
17/12/2019 - 18/12/2019

See key for explanatory notes

Tue 17 Dec 2019	09-09 Grass	09-09 MinT	09-09 MaxT	09-09 Rain	Sun	Wind From	Mean Wind	Max Gust	Significant Weather
Edinburgh, Royal Botanic Garden No 2 @5.4km W	-5.2°C	0.1°C	6.4°C	0.0mm					N/A
Edinburgh, Gogarbank @13.7km W	-0.2°C	3.0°C	6.1°C	0.0mm	1.1hr	220°	15mph	28mph	None

Wed 18 Dec 2019	09-09 Grass	09-09 MinT	09-09 MaxT	09-09 Rain	Sun	Wind From	Mean Wind	Max Gust	Significant Weather
Edinburgh, Royal Botanic Garden No 2 @5.4km W	-7.3°C	-1.9°C	10.3°C	1.2mm					N/A
Edinburgh, Gogarbank @13.7km W	-6.1°C	-1.2°C	10.3°C	1.8mm	1.5hr	120°	15mph	25mph	None

Values represent 24 hours commencing midnight GMT unless stated otherwise.

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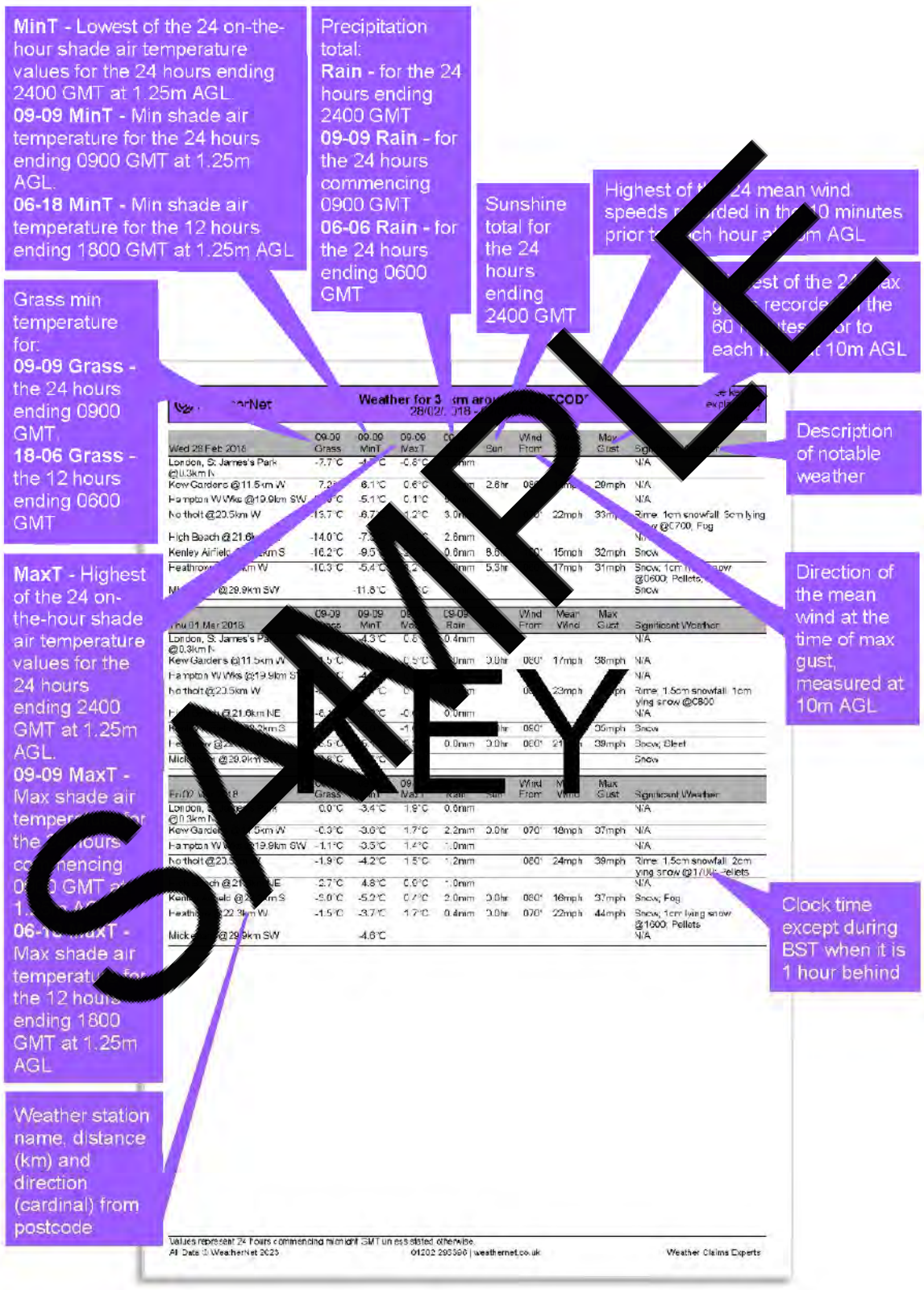
Daily Station Data - Key



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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 not by wind 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 ex s light flag
4	Moderate Breeze	15	13	18	Dust & loose paper raised; small branches m d
5	Fresh Breeze	21	18	24	Small trees in leaf begin to sway; crested elets form on t
6	Strong Breeze	27	24	31	Large branches in motion; whistling heard legraph w s
7	Near Gale	35	31	38	Whole trees in motion; inconvenience felt wh against the wind
8	Gale	42	39	46	Twigs break off trees; difficult to walk against win
9	Strong Gale	50	47	54	Slight structural damage to chimney pots, aerials & r tes
10	Storm	59	55	63	Trees uprooted; consi le structural damage
11	Violent Storm	68	64	72	Widespread structural dam
12	Hurricane	-	73	-	Devastation

Anecdotal evidence

No anecdotal reports were included in this meteorological report.

Interview & examination

None were conducted for this meteorological report.

Research papers

None were consulted for this meteorological report.

Measurement tests & experiments

None were conducted for this meteorological report.

The Author

I am the Chief Meteorologist at WeatherNet Ltd. WeatherNet Ltd is a subsidiary of the Claims Consortium Group. I have been employed by WeatherNet Ltd since the 10th July 1997. My qualifications include a CertHE in Environmental Science with Geographical Science (obtained June 1992), 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 1998), a Member of the National Geographic Society (since January 1993), a former Member of the Association of British Climatologists before it ceased (1995-2009) and a Fellow of the Royal Geographical Society (since January 2005). I have produced many 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 local chats/written quotes for local/national radio, TV, and newspapers. Finally, I have been credited and/or acknowledged to have worked on over 270 films and various TV programmes including Spectre, Harry Potter and the Deathly Hallows: Part 1/2, Alice Through The Looking Glass, 2017 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 and Founder of Heavy Snowfalls which is part of the Thunderstorm and Severe Weather Division and I have held this post since July 1998.

To date, I have prepared more than 2500 legal meteorological reports since the year 1997 and in the last five years, I have given evidence in court on two occasions (April 2018, and April 2019).

Dr Richard Dodd, Chief Meteorologist, has over 25 years of experience and, in association with WeatherNet, is listed as an expert witness on several expert witness websites including www.justicedirectory.co.uk, legalexperts-uk.com, www.thelawpages.com, www.postonline.co.uk, roundtablegroup.com, www.yourexpertwitness.co.uk, www.witnessdirectory.com, xperta.pro, www.thesolicitorsgroup.co.uk, www.braininjurygroup.co.uk, and www.localgovernmentlawyer.co.uk

I was (in association with WeatherNet Ltd) vetted by the Expert Witness Directory between January 2005 and October 2017, the Expert Witness Directory of Ireland between October 2010 and November 2016 and the Expert Witness Directory of Scotland between October 2010 and October 2016 before they ceased.

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

Affiliations

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

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

https://www.expertwitness.co.uk/expert/576[illegible]e2ca2f[illegible]af2228b5cc7 (since May 2012)

https://academyofexperts.org/search-register/prof-richard-wild/?register_type=2 (since June 2007)

https://www.newa.exp[illegible]/experts/dr-richard-wild/ (since January 2019)

https://www.apil.org.uk (since April 2007)

https://www.jspubs.com/index.htm (since February 2007)

https://www.lawscot.org.uk/WCM/ExpertWitnessProfile?ID=2379[illegible]ca-eea7-45b1-9d4b-68aba1ad2e83 (since November 2016)

https://forensicandexpertwitness.co.uk/experts/dr-richard-wild-weathernet-ltd/ (since January 2019)

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. These 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 of 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 (certain) ground based meteorological stations are unmanned, evaluations of certain meteorological parameters (present weather, visibility for example) may 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 09:00 GMT. This meteorological observation represents the past 24 hours' e.g., maximum and minimum air temperatures, rainfall, state of ground, sunshine etc. Main 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 09:00 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. Wind blows rain drops around a rain gauge and therefore the lower the rim (and therefore the lighter the wind) the better. However, if the rim of the rain gauge is too close to the ground, then in-splashing occurs. As a compromise, the standard rain gauge has its rim 30cm above the ground. The diameter is 5 inches (127mm), and rainfall can be measured to a resolution of 0.1mm. From a tipping bucket rain gauge perspective, this does not provide details of the timing of small amounts of rain. A tip of the rain gauge may be triggered in one hour when most of the rain fell in the previous hour. Rainfall (noted in millimetres and tenths) includes any solid precipitation, such as snow or hail which is melted and measured in the same way as rain. There may also be small additions due to deposition of dew, hoar frost, and rime ice on the collecting surface of the rain gauge. Rainfall amounts of <0.05mm are usually recorded as 'trace'. In some instances with automatic meteorological equipment, precipitation amounts less than 0.2mm (i.e., a few spots) will not be registered. Many rainfall stations in the UK are sited on Water Authority property, at reservoirs, sewage works and pumping stations. Daily rain gauges are normally read just once per day at 09:00 GMT, the recorded value being a single measurement of the rainfall of the previous 24 hours. To convert rainfall in millimetres to inches, multiply by 25.4.

Intensity of rain

Rain (as opposed to rain showers) falls from dynamically produced stratiform (layered) cloud like stratus and nimbostratus in association with frontal zones. Slight rain is rain of low intensity, which usually consists of scattered large rain drops, or many numerous smaller rain drops. The rate of accumulation in a rain gauge is less than 0.5mm per hour. Moderate rain is rain falling fast enough to form puddles quickly, where the down pipes flow freely and to give some spray over hard surfaces. The rate of accumulation in a rain gauge is between 0.5mm and 4.0mm per hour. Heavy rain is sufficiently intense to produce a roaring noise on roofs, forms a misty spray of fine rain droplets by splashing on road surfaces etc. and accumulates in a rain gauge at a rate greater than 4.0mm per hour. Moderate and heavy rain is normally associated with layered cloud of great vertical depth, normally in association 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 or 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 - 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 rain showers (the cloud type from which the precipitate falls 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. 1cm of snow is very roughly equal to 1mm. of rain. The range is from about 8 to 30 multiplied 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 in 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 seeding up other small droplets as it falls through moist, cloud 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 near 0°C, melting snowflakes with large, reflective surfaces give strong echoes. These produce 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 ground 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 (or 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 recordings are made at each (notional) clock hour. In most modern-day ground based meteorological stations; the thermometers use electrical resistance whereas in older ground based meteorological stations they are in 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 09:00 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 09:00 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 09:00 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 dry, moist, wet, flooded, 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 as 'rain'. Automatic rain gauges do not work well at temperatures below freezing point. Any 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 is 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 reported as 360 degrees represents a wind from due north (a northerly wind); 090 degrees is from the east (an easterly wind) etc. Wind speeds are recorded in knots (where 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 level 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 an anemometer. 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

AGL - Height Above Ground Level in metres.

ASL - Height Above Sea Level in metres.

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 limits 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 morning, 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 at or below 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 6º 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 dewpoint 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 dewpoint 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 dewpoint 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. Dewpoint may be measured indirectly from wet- and dry-bulb temperature readings with the aid of humidity tables, or directly with a 'dewpoint hygrometer'.

Freezing drizzle, freezing fog, freezing rain - Supercooled water drops of drizzle (or rain) which freeze on impact with the ground to form glazed frost or, in the case of small 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 a 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 a water surface. A funnel cloud is usually visible as a cone-shaped or rope 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 blades in an area covered with short turf.

Ground Frost - The term in forecasts signifies a ground minimum temperature of 0°C (32°F) or below, when ice forms on the ground, objects etc., causing water to freeze. Because the ground cools quicker than the air around a metre above, it is possible for a ground frost to occur without an air frost. This, as a general rule of thumb, usually occurs when the air temperature is <=3°C (39°F) with little or no cloud and light winds. From a layman's perspective this criterion is often shown as a yellow based snowflake on a car dashboard. A slight ground frost is when the ground temperature has fallen to 0°C or slightly below for a few hours, while a moderate frost is where ground temperatures have fallen to -2°C or below and/or for a noticeable longer period of time.

Gust front - is a leading edge/boundary (squall line) that separates a cold downdraft (outflow (winds that flow 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 on 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/Grass 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 horizontal distance. Downslope gravitational flow of the colder, denser air beneath the warmer, lighter air results and comprises the 'katabatic wind'.

Knot - Unit of measurement of wind speed. 1kt = 1.152mph = 0.514m/s.

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 which develops during the later stages of the life cycle of a frontal depression. The term arises from the associated occluding (shutting off) of the warm air from the earth's surface.

Okta - Unit, 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 - is 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 an increase in the sustained winds over a short time interval, and 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 forces 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 typhoons 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, temperatures, etc.) and show the presence or potential development of weather fronts and systems.

Thaw - The transition by melting from snow or ice to water. The 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 generally cloudy, 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 nearby 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 noted at the surface by a rise in temperature and dewpoint, a veer of wind direction and a steadying of pressure.

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