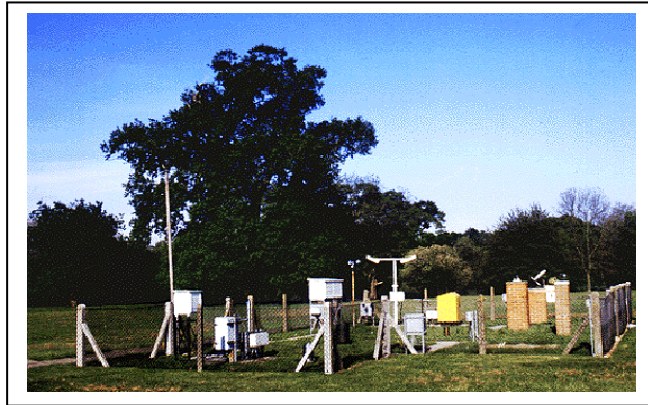


MIDAS Data User Guide for UK Land Observations



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1. Introduction

The Met Office has long been responsible for maintaining the public memory of the weather and the climate database, MIDAS, contains data from as far back as the 1850s. Meteorological observations made in the UK have been placed in an archive where they may be accessed today by those with an interest in the weather and where they will also be available to those in future generations. In the past, observations were recorded predominantly on paper forms which are now stored in the Met Office archives.

In 1959 a new system was introduced whereby all new climate data received at the Met Office was keyed and stored in digital format. At the same time a limited number of records for earlier years were also transferred into digital format so that some continuous climate sequences were available immediately. In the time that has elapsed since those days the digital climate record has been maintained and, as more automation has occurred, especially within observing systems themselves, the role of the paper record has declined.

The storage of climate data at the Met Office has developed over time, first as a collection of data on paper or magnetic tape, then, from the early 1970s as an organised database, the CDB (Climate Data Bank). The MIDAS (Met Office Integrated Data Archive System) relational database replaced the CDB in 1998.

The purpose of this guide is to describe the basic features of the **UK land** observing systems used, the way the observations have been processed and stored in the database and the general characteristics of the data.

2. Observing Systems and Sites

2.1 The UK land surface observing network

Surface observations over the UK meet many different requirements in such areas as forecasting, civil aviation, defence, commerce, industry, agriculture and research. Stations are organised into networks which are designed to meet particular user requirements.

Observations made primarily for the purpose of providing information on the present state of the atmosphere and for weather forecasts are termed synoptic. Synoptic observations over the land surface include measurements of a wide range of meteorological elements made at observing stations like Camborne in Cornwall (see figures 1 and 2). There are also supplementary stations which provide a more limited range of data to meet specific requirements, for example climate requirements, measurements of temperature and/or wind at a customer's site, and a dense rainfall network to aid water management and flood forecasting.



Figure 1. Land surface synoptic station (Camborne, Cornwall)



Figure 2. Wind tower

In the past, surface observing was predominantly a manual task whereby the observer read the instruments, made visual estimates of visibility, cloud, present weather and the state of ground, recorded the observation on paper, and, if the station produced SYNOP and NCMs (National Climate Message), encoded the report and transmitted it. An observation pad or pocket register was used for noting the observation as it was made, and a permanent record was made once the observation was complete. At synoptic stations the observations were recorded in the daily register in permanent ink, which then became the official record for the station. With the introduction of automated systems, the role of the human observer has diminished.

There was a convention, followed by the human observer, that where a value is read as half way between two points on the observing scale it is “rounded to the odd”, except for pressure which was rounded down. A value falling half way between 13.4 and 13.5 would have been reported as 13.5. As instrumentation became more automated then this practice was no longer required.

2.1.1 Observation time

The standard of time for all UK observations is Universal Time Co-ordinated, as required by WMO (World Meteorological Organisation). The meteorological convention for midnight is 0000 hours on the new day.

2.2 Synoptic stations

The distribution of synoptic stations is approximately uniform ensuring that as few weather features as possible escape detection. However, some weather features occur on small scales (for example showers) and may evade the surface network altogether.

Observations made at synoptic stations should represent the wider area around the station and not be unduly influenced by local effects. The ideal site should be on level ground with no trees, buildings or steep ground nearby that might influence the measurements. Undesirable influences include the warming effect of buildings on the measurement of temperature and the sheltering or shading effects of trees on the measurement of sunshine, wind and rainfall. Wherever possible, a station should not be located in a frost hollow where overnight temperatures on still clear nights may be far lower than at neighbouring locations. In a similar way, winds measured at the top of a hill or steep escarpment will be unrepresentative of the wider area.

Each station produces observations at minute intervals and the central database at Exeter contains a large store of minute data from all UK stations. For a great many years the standard observing time for synoptic purposes in the UK and for international exchange has been hourly, i.e. each station reports 24 observations a day at 0000, 0100, 0200, ..., 2200 and 2300 UTC. The central system at Exeter generates hourly observations encoded in internationally agreed formats for onward transmission in real time to users worldwide.

Although most of the observing process is automated today, there are some synoptic stations where a trained meteorological observer provides some input into the observation. Usually this occurs at airfields where the observer can provide estimates of visibility, cloud type, cloud amount and state of ground. As there are no sensors to identify cloud type or state of ground, these elements are not available from automated sites.

The following meteorological elements are measured at synoptic stations:

Air temperature at 1.25 m above the ground

Air temperature over a grass surface or its artificial equivalent

Concrete temperature

Soil temperature at 0.1 m, 0.3 m and 1.0 m below the ground level

Relative humidity at 1.25 m above the ground

Amount of rainfall

Depth of lying snow

Mean wind speed, mean wind direction and maximum gust 10m above the ground

Atmospheric pressure at the station level and reduced to mean sea level

Pressure tendency and characteristic

Visibility

Amount of cloud

Type of cloud identified by observer

Height of cloud base

Present and past weather

Duration of sunshine

Short wave solar radiation intensity**State of ground and of concrete slab** identified by observer

2.3 Supplementary stations

In addition to the synoptic stations described above there are a number of supplementary stations that provide a more limited observing capability. Examples of these include stations:

- Designed to meet the needs of a particular customer;
- In the urban environment;
- Sited at the top of mountains;
- Meeting the requirement for a long climate record.

Many stations are maintained to meet the requirement for accurate climate averages at a wide variety of locations over the UK. Some climate stations are automated, sending data in real time, and some rely on a voluntary observer making a daily observation at 0900 UTC from manually read instruments, who may send the data daily or at the end of the week or month. The principal observed elements for climate purposes are:

Maximum air temperature at 1.25 m above the ground (0900UTC-0900UTC the next day)**Minimum air temperature** at 1.25 m above the ground (0900UTC-0900UTC the next day)**Air temperature** at 1.25 m above the ground (0900 UTC)**Grass minimum temperature** (0900 UTC (or dusk at some manned sites) to 0900 UTC the next day)**Soil temperature** at 0.1 m, 0.3 m and 1.0 m (0900 UTC)**Relative humidity** at 1.25 m above the ground (0900 UTC)**Rainfall amount** (0900 UTC to 0900 UTC the next day)**Depth of lying snow** (0900 UTC)**Sunshine duration** (0000 UTC to 2300 UTC)

2.3.1 Auxiliary Observing stations

The surface observing network was enhanced by a number of auxiliary observing stations. The observers at these sites were mainly volunteers with the instruments and screen contained on their land.

The observing schedule from these sites was a mix of hourly, 3 hourly and 6 hourly. The process was similar to that of the Met Office observer with the readings noted and coded up in an abbreviated version of the daily register. There were no automated elements to aid the observer.

It was the responsibility of a Met Office outstation to collect the observations by phone and transmit them forward to a Weather Centre. The Auxiliary Observers received payments depending on how many observations and how many elements they reported.

During the early 1990s an observations processing system for the auxiliary observers called CODET (Computerised Observation — Data Encoding and Transmission) was developed. This was a laptop with a disc providing the software to allow for the input of the readings. The observation on this system was automatically coded and a minimal amount of QC carried out at source before it was sent via a phone line.

The Auxiliary Observing Network was reduced significantly during the early part of the 2000s with sites automated or closed.

2.3.2 Voluntary Climate Stations

In the past all daily observations at voluntary climate stations were recorded on a variety of different form types with the most recent being the METFORM 3208b. These were sent to the Met Office at the end of each month for ingestion into MIDAS. During the early 1990s a new system for logging Climate Observations called Discs 2 was developed. Climate Observers with access to a computer had the opportunity to input their daily readings onto a floppy disc and send the completed disc for keying at the end of the month.

In 2007 an online web page called OWL (Observer Weather Log) went live that allowed observers to submit their observation online on a daily basis. This was followed in 2009 by OWL 2 which was an updated version. This system replaced the previous Discs 2 method of submitting observations.

During the spring of 2011 the voluntary climate observers were encouraged to use WOW (Weather Observations Website) which is a web page where members of the general public can also send in weather observations and OWL was withdrawn. Not all observers have computer access to the internet, leaving a minority that continue to send in their monthly data via the METFORM 3208b.

2.3.3 Rainfall stations

Measurements of rainfall amount often vary greatly from location to location because of the variable nature of rain producing weather systems and their interaction with high ground. For this reason a high density network of rain gauges is required to define the rainfall climatology of the UK and to identify where flooding events are likely to occur as a result of local heavy storms. By far the most numerous type of supplementary observing site is the rainfall station where the only measurement made is rainfall amount. Some systems are automatic sending data in real time while others rely on manually read rain gauges where the data may be received some time after the event. Organisations such as the Environment Agency and the Scottish Environment Protection Agency operate many of the rainfall stations.

2.4 Automatic observing systems

Automation, which began in the 1970s, now affects virtually all aspects of synoptic observing, and to an increasing extent, the observations from the climate and rainfall networks. As observing technology has improved over time, there has been the gradual replacement of one type of instrumentation by another. There have been changes from a manually read instrument to a fully automated instrument and also changes in the types of sensors used.

2.4.1 Rainfall and wind loggers

A number of rainfall and wind logging systems were installed at Met Office stations from the 1970s onwards. The data was recorded on magnetic medium at the site and transferred at monthly intervals to the climate database. The SSER (Solid State Event Recorder) and MTER (Magnetic Tape Event Recorder) loggers for rainfall are covered in section 3.8.5 and appendix C, and the DALE (Digital Anemograph Logging Equipment) logger for wind is covered in section 3.7.5, all of which are now not in use.

2.4.2 SAWS, ESAWS, SIESAWS and CDL

The Synoptic Automatic Weather Station (SAWS) was the first fully automated observing system deployed in any number by the Met Office. The system operated at many remote sites and provided hourly SYNOP messages from the mid-1980s.

It was later replaced by the Enhanced SAWS (ESAWS) which was capable of producing hourly climate messages (HCM) and 12-hourly national climate messages (NCM) in addition to the SYNOP. A version designed to operate in severe icing environments, SIESAWS, was installed at a few high level locations.

Climate Data Loggers (CDL) of a number of different designs were installed at a number of sites during the 1990s; most recorded the main synoptic and climate parameters and there was a facility for polling the data remotely. Each of these were developed for use as real time observing systems.

2.4.3 SAMOS

The Met Office developed SAMOS (Semi-Automatic Meteorological Observing System) and CODET (Coded Observation Data Entry Transmission) in the mid-1990s to aid the production of observations. Both were PC based systems and SAMOS could generate the full range of messages for a synoptic station (SYNOP, NCM, SREW, HCM). CODET was specially designed to operate at auxiliary stations with manual data and as a result could only code SYNOPs & NCMs.

The observer could add to or modify any part of the SAMOS observation through the PC and some quality control checks were incorporated into the interface. The SAMOS system was able to operate automatically by default at any synoptic hour if no observer input had been provided by a specific time (set at HH-5min) for selected hours at stations which are only part manned, and for all hours where the system had been installed at an unmanned station. It was also able to undertake 10-minute observations required by general forecasting practice.

2.4.4 MMS

The Met Office developed MMS (Meteorological Monitoring System) to replace the various AWS systems detailed above. MMS collects data at one minute resolution at each station and generates the full range of messages that the old systems used to produce (SYNOP, NCM, SREW, HCM). The observer can add to or modify any observation through the PC interface and QC checks are incorporated into the system. The observation can be corrected after it has been sent or can be resent if the transmission fails.

2.5 Station identification and naming

For each station there are a set of identifiers which serve 3 purposes: identification of the station, identification of the origin of the meteorological reports from the station, and identification of the instrument or instruments used for observations from the station. Five types of identifier are used:

Station Identifier	Description
WMO number	Identifier used for international exchange
ICAO identifier	Identifier used for aviation stations only; defines the airfield

DCNN number	Identifier used for national climatological purposes
Rainfall number	Gauge identifier, doubling up as station identifier at rainfall only sites
Wind number	Wind system identifier of format DCNNnn, where nn=01,02,03

Over time certain instruments, or the whole enclosure, may be relocated some distance away from the original site. Where the distance moved is small, the observations obtained from the new site may have the same climatological characteristics as previously and it makes sense to regard them as coming from the same source with the same identifiers. Where the distance moved is large, or, where the exposure at the new site is sufficiently different that a detectable impact on the measured climatology is judged likely, it is appropriate that observations from the new site are associated with a new identifier; rainfall number if the rain gauge has been moved, DCNN if the enclosure has been moved, and wind number if the anemometer mast has been moved.

Over the years, the observation branches of the Met Office have followed an agreed set of rules to determine whether measurements should be considered as originating from a new source when the conditions under which the observations are made change, such as significant changes in the station location or height. Prior to 2012, a new identifier was also allocated if the rainfall collecting equipment changed.

2.5.1 WMO number

Synoptic stations selected as suitable for possible international exchange are given a 5-figure WMO number which is used as the identifier for all SYNOP and SREW reports. It is also used as identifier for climate reports, NCM and HCM, exchanged within the UK in real time. The first 2 figures of the WMO number are 03 which is the block number for the UK and Ireland. Numbering runs from north to south across Britain followed by Ireland.

2.5.2 DCNN number

All stations that are part of the climate network have a 4-figure DCNN (Daily Climatological Network Number). In general, if a station moves more than 800m in a region of homogeneous terrain it is allocated a new DCNN, while a lesser distance will justify a new DCNN only if it is considered that the exposure at the new site is sufficiently different to affect the measured climatology.

2.5.3 ICAO identifier

Stations that are part of the aviation network have a 4-character international ICAO number. Where the first two characters are EG, this represents Europe-UK.

2.5.4 WIND number

Like rainfall number, the wind number identifies the characteristics of the observing site. Each anemometer mast has a 6-figure wind number of the format DCNNnn, where nn=01,02,... is the anemometer site number. A new site number is allocated to the observations if the mast is repositioned but not if the height of the anemometer is changed. A station may therefore be associated with several wind numbers.

2.5.5 RAIN number

All stations that are part of the rainfall network are given a 6 figure rainfall identifier (id) unique to the gauge at the site. For example a manned station is likely to have an automatic gauge along with a manually read check storage gauge. These would have separate rain identifiers despite being situated near to one another at the same station.

2.5.6 CLBD, CLBN, CLBR numbers

These fall under two categories:

1.

Sites that were previously known as CDL sites and were installed for specific business reasons and may have been located at non-standard locations e.g. a roof top. All of these commercial stations can have WMO, DCNN, RAIN and WIND id type capabilities open at the station, in the same way that any normal station can have. However, to make it apparent that the station is a commercial site, each id type has the prefix CLB before it followed by the first letter of the relevant id type. The following id types are used:

WMO – CLBW

DCNN – CLBD

RAIN – CLBR

WIND - CLBN

In the MIDAS.SRC_CAPABILITY table each of these capabilities will have a PRIME_CAPABILITY_FLAG of 'T', therefore the data for these are stored in the MIDAS tables as 'WMO', 'DCNN', 'RAIN' or 'WIND' IDs, but the ID_TYPE given will be 'CLBW', 'CLBD', 'CLBR' and 'CLBN' respectively.

2.

MINI-MMS sites (automated former voluntary climate sites with ID_TYPE = DLY3208, or former non-business specific CDL sites). These are given a WMO number to allow for transmission on the GTN. These are 5 digit numbers beginning with 99. The ID_TYPE is CLBW. However, the PRIME_CAPABILITY_FLAG in the MIDAS.SRC_CAPABILITY table is set to 'F' which means that there are no data under this CLBW ID type in MIDAS. Instead, these sites also have a DCNN number with ID_TYPE = DCNN, and these have a PRIME_CAPABILITY_FLAG = 'T' which means that data are stored under the DCNN ID type in MIDAS.

2.5.7 Rules for station identification

The definition of stations in MIDAS will follow the following rules. Some changes to the practices of the observations branches may be desirable to take advantage of the structure provided by both the MIDAS and Metadata databases.

1. A station is a collection of instruments and observing systems, existing today or for periods of time in the past, which together may be considered as a common source of observations associated with a given location.
2. Each station may be considered as being made up of a number of clusters of instruments or observing systems, each defined by its location relative to the station position. Any 2 clusters will be regarded as belonging to the same station if:
 - (a) at the present time or at some time in the past, observations from both clusters have been reported under the same identifier (WMO/DCNN/ICAO/Rainfall/Wind), or,
 - (b) one cluster may be considered as taking over the role of the other cluster on its closure.
3. Each of the identifiers WMO/DCNN/ICAO/Rainfall/Wind will be associated with one and only one station. Where this rule has been broken in the past in the case of WMO numbers, a letter will be added as a suffix.

Some identifiers have been re-used, e.g. when a WMO station number is re-allocated at a later date for a site that is deemed suitable for synoptic purposes. Where this has happened already the oldest use will have the character Z appended to the identifier, the

next oldest Y, etc, with the over-riding proviso that the newest version will NOT have an appendage.

Each station may have more than one WMO, DCNN, Rainfall or Wind number.

4. Each source in MIDAS, identified by the attribute `src_id`, will be associated with a station as defined above and there will be a one-to-one correspondence with stations in the Metadata Database.
5. Each station in MIDAS will be uniquely defined by its name. There will therefore be a one-one correspondence between `src_id` and station name. It is envisaged that the name will be the principal means of station identification for users.
6. At stations having a complex observing history there may be alternative sources for a given meteorological parameter. Each reporting capability will have an entry in the source capability table and will refer to a set of data records in MIDAS stored under a particular 'Met domain' and identifier (see section 4.3). To simplify data extraction for those users unfamiliar with the observing history at the station the concept of **prime capability** has been introduced. Where an entry in the source capability table has been identified as prime, the corresponding data records are preferred and are guaranteed free of duplicates. Gaps in the data records of any prime capability cannot be ruled out, and non-prime sources should be searched to achieve a complete set of observations from the database. At any station, the primary capability may change following changes to the site or instrumentation.
7. The **station position** is the current position of the primary gauge and is stored in the Source table under the station's source identifier. Where the enclosure or individual instruments have moved, their locations at various times in the past will be recorded relative to the station position and the information stored in the Metadata Database. The reference position of the station in the Metadata Database will be the same as the station position stored in MIDAS. Using MIDAS alone, all instrument clusters associated with a station will be assigned the same position, that of the station. Careful checking must be done when accessing data to ensure that there has not been instrument position changes across the period

The **source capability table** (see section 4.2) defines the relationships between the various identifiers of a station and the data types stored.

3. Data characteristics and instrumentation

3.1 Introduction

This section gives background information on the characteristics of the data stored within MIDAS, and the types of instrumentation used, and highlights significant changes in practice over time.

3.2 Observation time

The standard of time for all UK observations is UTC (Coordinated Universal Time), as required by WMO. The meteorological convention for midnight is 0000 hours on the new day.

The UK practice since the 1960s, and possibly from an even earlier date, has been that observations are typically completed by HH-10 each hour, where HH is the time, in whole hours UTC.

3.3 Stevenson Screens

Measurements of air temperature and relative humidity are made in a screen that shields the instruments from direct sunlight. The screen is positioned so that the thermometer is 1.25 m above the ground and its door faces north to ensure that no sunlight falls on the instruments when being read or serviced. The screen type currently in use at Met Office stations (figures 3 and 4) is based on an original design by Thomas Stevenson (1818-1887) and relies on natural ventilation. It is constructed of plastic, coloured white outside and black inside, with double roof, floor and side louvers that serve to reduce the amount of heat that would otherwise be conducted from the outer wall to the inner enclosure, especially in strong sunshine. Free circulation of air throughout the screen allows the temperature of the inner wall to adapt to ambient air changes, a design that is not immune from problems in extreme cases. Anomalies may arise when the wind is light and the temperature of the outer wall is markedly different from the air temperature. Although the plastic screen is used in the observing network today, wooden versions were used in the past.



Figure 3. Stevenson screen



Figure 4. View inside the screen

3.4 Temperature

3.4.1 Overview

The resolution of the measurement in the meteorological report has varied over the years and is reported in degrees Celsius to one decimal place at the moment. In the past, the original measurement may have been reported in Fahrenheit and/or to the nearest 0.5 degrees or 1 degree. All temperatures in MIDAS have been converted to degrees Celsius and are stored with a resolution of 0.1 degree Celsius (apart from METARS which report temperature as integers). The J-descriptor indicates the original units of observation (See section 5. Quality Control).

Instruments are calibrated on receipt from the manufacturer and at intervals after deployment with the aim of ensuring that the accuracy of the measurement is better than 0.2 degrees Celsius. Traceability to national standards has been maintained since the 1850's and corrections determined from the calibration are applied to most observations made with the instrument.

3.4.2 Electrical resistance thermometers

Electrical thermometry is now in widespread use. Platinum resistance thermometers (PRT) first came into regular use in the early 1980s at the fully automatic SAWS (Semi Auto Weather Station) stations. For air temperature measurements, the thermometer is exposed in a Stevenson screen of the type described in the preceding section, at a height of 1.25 m above the ground and aspirated only by natural ventilation through the side louvers. Figure 4 shows the arrangement of thermometers in the screen. Two PRTs, one for operational use and one acting as a backup, may be seen at the end of the looping black cables. In addition, there are four liquid-in-glass thermometers in the screen that are used solely for check readings, though as sites have become automated these have mainly been removed. Temperature measured by a PRT is related to the resistance of the instrument's platinum wire. The thermometer is calibrated every 8 years providing traceability to the national temperature standard.

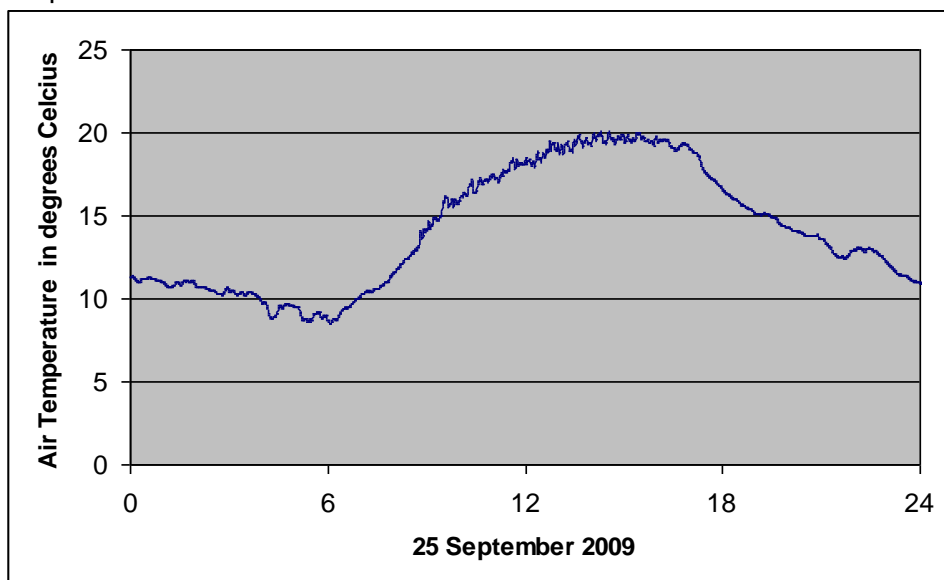


Figure 5. 1-minute values of air temperature at Heathrow Airport on 25 September 2009

An example of air temperature over a 24-hour period is shown in figure 5 for a typical sunny day in southern England. Measurements taken every 15 seconds are averaged to provide the underlying 1 minute data. Maximum and minimum temperatures are defined as the extreme 1 minute values during the relevant period. Daily maximum and minimum

temperatures normally refer to a 24-hour period 0900 UTC to 0900 UTC. In the example below, the maximum temperature on the 25 September is 20.1 °C (the maximum value between 0900 UTC on the 25th and 0900 UTC on the 26th). The minimum temperature is 8.5 °C (the minimum value between 0900 UTC on the 24th and 0900 UTC on the 25th).

3.4.3 Liquid-in-glass thermometers

At non automated climate stations where the temperature is taken by the human observer, liquid-in-glass thermometers meeting British Standard specification BS692 are used. Traditionally, air temperature was measured by a normal mercury-in-glass thermometer, maximum temperature by a mercury-in-glass thermometer having a constriction in its bore that holds the mercury in its highest position, and minimum temperature by an alcohol-in-glass thermometer which carries a small index within its bore for marking the lowest temperature reached. The observer resets the maximum and minimum thermometers daily at 0900 UTC. Following the Minimata Convention in 2017, all mercury thermometers were removed from the network and were replaced with an electrical thermometer (a PRT). Liquid in glass thermometers are calibrated every 5 years.

3.4.4 Grass and Concrete minimum temperature

The grass minimum temperature is the lowest temperature reached by a thermometer freely exposed to the sky with its bulb just touching the tips of short grass (25 to 50 mm above the ground).

With the advent of widespread automation, the natural grass surface under the grass minimum thermometer has been replaced by an artificial equivalent at most automatic stations. A platinum resistance thermometer is used for the measurement of grass minimum temperature at almost all synoptic stations and all supplementary stations that employ an automatic system (figure 6). Alcohol-in-glass minimum thermometers exposed over natural grass are used at manned climate stations.

The concrete minimum thermometer is exposed at the centre of, and in contact with, a concrete slab which should be cleared of any snow (figure 7). The slab lies horizontally, fully exposed to the open sky and with its top almost flush with the surrounding ground. Platinum resistance thermometers are used at almost all stations with automatic systems, while alcohol-in-glass minimum thermometers are used at manned climate stations. Concrete minimum measurements have been made at Met Office stations since 1 December 1968 and are mainly relevant to the incidence of ice on runways or roads.



Figure 6. Grass minimum thermometer over an artificial surface

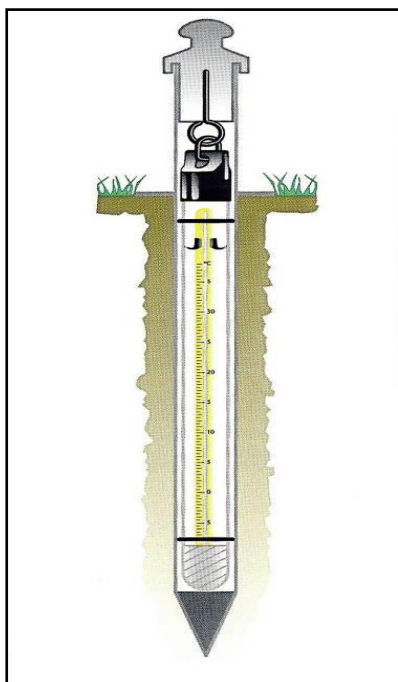


Figure 7. Concrete minimum grass thermometer

3.4.5 Soil temperature

At many stations temperatures below the surface are measured at various depths. The depths used currently are 10, 30 and 100cm, though 5, 20 and 50cm have been used in the past. Measurements are not necessarily made at all these depths at a station. When imperial units were in general use, typically before 1961, the normal depths of measurement were 4, 8, 12, 24 and 48 inches.

At many stations with automatic systems, soil temperature is measured at a depth of 10 cm, 30 cm and 100 cm below the ground surface by platinum resistance thermometers. Thermometers at 10 cm and 30 cm are buried by inserting the head at the required depth into the undisturbed soil on the vertical wall on the side of a trench which is then back-filled. This method is impractical for the 100 cm measurement; instead the thermometer is suspended inside a tube with its tip at the appropriate depth. Problems can occasionally arise where the tube becomes flooded due to waterlogged soil or heavy rainfall. To ensure consistency of measurement from site to site, the ground surface above the 10 cm soil thermometer is maintained as bare soil.



At manned climate stations soil temperature was measured by mercury-in-glass thermometers read by the observer. Thermometers for the 10 cm measurement have a right angled bend in the tube so that the bulb may be buried in the soil at the required depth and the scale exposed horizontally above the surface for easy reading. Normal mercury-in-glass thermometers are suspended inside tubes for the 30 cm and 100 cm measurements (figure 8). These thermometers are housed in an extra protective glass sheath and have their bulb set in wax to slow their response while being withdrawn and read by the observer. Mercury thermometers were replaced with alcohol thermometers in 2017.

Figure 8. Soil thermometer exposed in a tube

3.4.6 Temperature measurement – Sources of error

Errors with manually read thermometers include:

- Gross errors of the manual reading
- Breaking of the liquid column
- Maximum, Minimum, Grass Min and Concrete thermometers not properly reset the previous day
- Bubbles appearing in liquid thermometers giving inaccurate readings

Errors associated with electrical resistance thermometers (ERTs) include:

- Equipment faults

- ERTs for grass and concrete minimum temperatures at automatic sites may become buried by snow

3.5 Atmospheric Pressure

The atmospheric pressure is currently recorded in hectopascals and tenths. Mercury barometers were commonly used until 1968, when the precision aneroid barometer (PAB) was phased in. The barometer was generally attached to an inside wall, though in the case of the PAB it could have been put on a purpose made shelf. Daily check readings were made with the station check/spare barometer, and every six months a replacement newly calibrated barometer was provided by the Met Office QA lab. During the 1990s, the precision aneroid barometers were replaced by automated pressure sensors.

Atmospheric pressure is now measured by a barometer that employs a silicon capacitive pressure sensor having excellent repeatability and long term stability characteristics (figure 9). To ensure any errors are kept to the absolute minimum, the instrument contains 3 separate pressure sensors and internal instrument software checks for any differences between the 3 independent measurements.

The deployment of a pressure sensor in the field must be undertaken with great care. Any movement of air across the vent that connects the sensor to the ambient environment will cause a drop of pressure caused by a simple dynamical effect described by Bernoulli's principle. Similarly, the pressure in still air within a building will be affected by the flow of air round the building or indeed by an air conditioning system. To avoid erroneous measurements, the pressure sensor is exposed via a static pressure head (figure 10), a device designed in such a way that the dynamical effects of wind are minimised.



Figure 9. Pressure sensor



Figure 10. Static pressure head

Atmospheric pressure varies greatly with height, dropping near the surface by about 1 hPa (or 1 millibar) for each 10 m in the vertical. To make sense of pressure readings from a network of barometers across the UK, each exposed at a different height above sea level, all values of station level pressure are converted to an estimate of the pressure at mean sea level, using a formula that takes into account the air temperature. Mean sea level pressure (MSLP), station level pressure and the pressure tendency during the previous 3 hours are reported from all synoptic stations every hour.

Both Station Pressure and MSLP are stored in MIDAS to a resolution of 0.1 hPa, with the Station Level Pressure for non-high level stations being stored since 1999. Pressure tendency is not stored in MIDAS.

3.6 Humidity

3.6.1 Overview

In MIDAS, the relative humidity, expressed as a percentage, is stored to 1 decimal place. MIDAS also stores the wet bulb temperature and dew point temperature with a resolution of 0.1 degrees Celsius.

3.6.2 Wet bulb thermometer

In the past, observations of relative humidity were derived from two liquid in glass thermometers ventilated naturally in the Stevenson screen: a dry bulb measuring the air temperature and a wet bulb measuring the temperature of a thermometer tip wrapped in a moist muslin wick and cooled by evaporation into the surrounding air. A few stations also had a relative humidity instrument such as a hygrograph. On occasions when air temperatures fall below zero, the wet bulb would be covered by a thin film of ice (ice bulb), this being ensured by the observer at manned sites each time a reading is taken. Conversion to a dew point used values of saturated vapour pressure with respect to an ice covered surface. Voluntary climate sites will still use liquid in glass thermometers to derive a relative humidity observation.

As sites became automated, the liquid in glass thermometers were replaced by ERT thermometers at synoptic sites, but the same principle of deriving relative humidity from the dry and wet bulb thermometers was used.

3.6.3 Humidity probes

From about 2006, most synoptic sites in the UK used humidity sensors which measure the capacitance of a hygroscopic dielectric material placed between two electrodes. Using air temperature, this measurement may be converted to relative humidity or dew point. The sensor (coloured white and on the left in figure 4) is ventilated naturally in the Stevenson screen alongside the air temperature thermometer. To avoid contamination by pollution or salt particles, problems most acute in the urban or marine environment, the sensor is shielded by a fine filter which is replaced at regular intervals by service engineers. At regular intervals, relative humidity probes are calibrated in the laboratory by comparison with absolute measurements of humidity from a chilled mirror device.

3.6.4 Humidity measurement - Sources of error

Errors with manual readings include:

- Errors in the readings of the dry and wet bulb thermometers
- Contamination of the wick, especially where it has not been changed sufficiently frequently or impure water has been used.
- Drying out of the muslin wick of the wet bulb thermometer.
- Poor ventilation on a calm day.

Errors with humidity probes described in 3.6.3 include:

- Tendency to be slow to recover from saturation resulting in an over-estimation of the relative humidity.

3.7 Wind

3.7.1 Overview

Wind is the horizontal movement of air and is specified by its speed and direction. The normal unit of wind speed is the knot (nautical mile per hour = $0.51 \text{ m sec}^{-1} = 1.15 \text{ mph}$). Wind direction is measured relative to true north (not magnetic north) and is usually reported as an averaged direction from which the wind is blowing in degrees. The maximum observed speed over a specified time interval and the time of occurrence may also be reported. Where observations of wind speed from overseas stations are in ms^{-1} , values are converted to knots before storage.

The data are reported to the nearest knot and 10 degrees in the SYNOP and HCM messages, and in the past on Form 6910.

Wind speed and direction were recorded on an anemograph in the past and the mean values and gust speeds were estimated by human analysis. Estimates of average speed from a continuously changing dial, which are subject to large error, were also made at a few stations in the supplementary network. This observing practice was phased out during the late 1990s and early 2000s.

Because wind is an element that varies rapidly over very short periods of time it is sampled at high frequency to capture the intensity of gusts, or short-lived peaks in speed. Since the introduction of MMS, wind speed and direction are sampled every 1/4 second. One minute average values are obtained and then used to produce the final 10 minute mean and hourly mean values sent in the SYNOP and HCM reports. 10-minute averaged winds reported in the SYNOP message are for the period HH-20 to HH-10. Hourly mean winds in the HCM message and gusts reported in the SYNOP message are for the period HH-70 to HH-10.

Some Ordinary Climatological Stations used to report run of wind from a cup counter anemometer on a 2 m mast. This was converted to a 24-hour mean wind speed in knots for storage in MIDAS, but was declared obsolete from 2001.

3.7.2 Wind measurement

Wind speed normally increases with height above the earth's surface and is much affected by the presence of buildings, trees and other obstacles in the vicinity. Wind over the land surface is usually measured at a height of 10 m above ground level at the top of a mast or some other supporting structure that has small impact on the local flow of air. The optimal exposure for the measurement of wind is over level ground of uniform roughness with no large obstacles within 300 m of the tower. In practice few sites in the observing network meet this requirement exactly for all incident wind directions, but most are reasonably representative of an open site.

Wind speed is normally measured by a cup anemometer mounted on a vertical spindle. The wind blowing into the cups causes the spindle to rotate. In standard instruments the design of the cups is such that the rate of rotation is proportional to the speed of the wind to a sufficiently close approximation. At regular intervals, anemometers are calibrated in a wind tunnel to identify any departures in the relationship between spindle rotation and wind speed specified by the manufacturer. Calibration corrections are applied to the measured wind speed.

Wind direction is measured by a vane consisting of a thin horizontal arm carrying a vertical flat plate at one end with its edge to the wind and at the other end a balance weight which also serves as a pointer. The arm is carried on a vertical spindle mounted on bearings which allow it to turn freely in the wind. The anemometer and wind vane are each attached to a horizontal supporting arm at the top of a 10 m mast (figure 11).

Where wind measurements are made in extreme weather conditions, such as on the top of mountains, a heated sonic anemometer is used (figure 12) having no moving parts. The instrument measures the speed of acoustic signals transmitted between two transducers located at the end of thin arms. Measurements from two pairs of transducers can be combined to yield an estimate of wind speed and direction. The distortion of the air flow by the structure supporting the transducers is a problem which can be minimized by applying corrections based on calibrations in a wind tunnel.



Figure 11. Cup anemometer and wind vane



Figure 12. Sonic anemometer

The Munro Mk4 cup anemometer and vane were the basic instrumental method for measuring wind in the UK for many years. However at present there are currently no sites that still use these. The cup had a large inertia and therefore had a relatively slow response time, with a start-up speed of about 6 knots. In 1998 a project began for the replacement of Mk4 anemometers by a lightweight anemometer with better response characteristics, the Munro Mk6.

3.7.3 Other wind measuring methods

In the past, visual estimates of wind have been made at a number of stations in the supplementary network and the observations have been reported as 10-minute winds in the SYNOP message.

Dines pressure tube anemometers, which had a better response at low wind speeds than the Munro Mk4, were installed at a number of stations in the early years of observing, but none of these instruments are currently in use today.

In the past, SIESAWS systems used an orthogonal arrangement of pressure tubes to measure wind which did not prove reliable in the extreme environment in which they were sited. Light winds were not handled well and had a bias reset which corrected the error. Water collected in the pressure tubes and caused incorrect wind values. These sites have all now been converted to MMS and have ultrasonic anemometers installed. These heated

anemometers are designed to reduce ice forming on the sensors in extreme weather conditions which make them ideal for mountain stations. These were installed during 2008 and 2009.

3.7.4 Earlier wind analysis and processing methods

With the arrival of MMS and minute wind data, all the early methods of wind analysis and processing are no longer used. Details regarding these methods are shown below:

Form 6910 – This contained hourly mean wind, direction and maximum gusts and the speed, direction and time of the maximum gust each day. The following rules were applied when analysing the anemograph record:

Time was determined from the daily time marks made by the observer. The observing period was defined as HH-60 to HH-0.

Mean wind speeds were estimated to the nearest knot but a value of 1 knot was not normally reported. Where the mean speed was 0 or 1 knot and the wind vane showed gusty, but not smooth variations, the speed was reported as 2 knots and the gust as missing. A mean speed of 0 was only reported if the speed trace indicates calm over the complete 1 hour period and the vane is unmoving or records only smooth variations.

Maximum gust speeds in each hour were analysed unless 2 knots were reported as above. The direction of the maximum gust during the 24 hour period was reported, but not the direction of the maximum gust in each hour.

DALE logging system - minute speeds and directions were processed to provide mean hourly winds for the period HH-60 to HH-0. For a number of years after its installation the processing method attempted to mimic the Form 6910 analysis method, in particular, no instances of 1 knot mean speed were allowed. This practice was discontinued in the mid-1990s after which date simple hourly averages of the minute data were calculated.

3.7.5 Wind measurement - Sources of error

Potential sources of error (past and present) in the measurement of wind include:

- Poor exposure at the site. Exposure may change gradually with time, for example as nearby trees grow, leading to slow changes in the climate record.
- Poor response in low wind speeds for the Mk2 and Mk4 Munro anemometers
- Stuck wind vane and anemometer
- Inaccurate estimation in the case of visual observations of wind.

3.8 Precipitation

3.8.1 Overview

The total amount of precipitation which reaches the ground over a stated period is expressed as the depth to which it would cover a horizontal surface. The reported accumulation of rainfall is the sum of the amount of liquid precipitation plus the liquid equivalent of any solid precipitation (that is the liquid obtained by melting snow or ice that has fallen). Similarly, the depth of snowfall is expressed by the depth of fresh snow covering an even horizontal surface. The unit of rainfall is the mm and amounts are normally measured and reported to the nearest 0.2 mm, and where possible, to the nearest 0.1 mm. Snowfall is measured and reported to the nearest cm. Trace is reported where precipitation is observed during the period, but the amount would otherwise be reported as zero.

The inch was the unit of rainfall in the past and amounts were usually measured and reported to the nearest 0.01 inch, but other resolutions were in use at a few stations. Inches were the sole unit of measurement in the 19th century and mm the sole unit since 1970, but in the long period between these dates the reporting practice varied from station to station. All rainfall accumulations in MIDAS have been converted to mm and are stored with a resolution of 0.1 mm. The J-descriptor indicates the original units of observation (see section '5. Quality Control' for further explanation).

3.8.2 Storage raingauge

Since the earliest years of weather records, the standard for the measurement of daily rainfall has been the 0900 UTC reading made by an observer from a 5 inch storage rain-gauge. The gauge has a sharp brass or steel rim of diameter 5 inches (127 mm), sited 30 cm above ground level with a funnel that collects rain in a narrow necked bottle placed in a removable can. To make the rainfall measurement, the observer empties the collected rain into a graduated glass rain measure. Figure 13 shows the type of storage rain-gauge used widely in the UK. Versions of the 5 inch gauge with greater storage capacity are used at sites where readings may be taken infrequently. As automated instruments were introduced across the synoptic network in the 1980s and 1990s the 5 inch gauge was still deployed alongside the tipping bucket gauge to continue a long consistent record of measurements for climate purposes. In recent years this practice has proved impractical and many automatic sites now only report rainfall amount from a tipping bucket gauge. Storage gauges are still used widely at non automated climate stations and rainfall-only stations. Where an observer is not available to provide daily rainfall, readings may be made at weekly or monthly intervals.

Exposure of the gauge should be on open ground distant from the effects of sheltering objects. At a few windy sites there may be a surrounding turf wall of diameter 3 m and height 30 cm which shields the gauge from the extreme effects of strong winds. It is not current practice to build turf walls at new stations, although they are maintained at existing sites.

Many different types of rain-gauge have been designed and used. Most consist of a circular collector, delineating the area of the sample, and a funnel that channels the collected rain into a measuring mechanism or into a reservoir where it may be measured at a later time. As the name implies, rain gauges measure rain not snow, hail or other forms of frozen precipitation. The entrance to the gauge through the funnel is narrow to avoid debris clogging the mechanism and undesirable evaporation in hot weather. However, the gauge rapidly becomes blocked in snow and any readings at the time, and during thawing events when melted snow gradually trickles into the gauge, should be treated with caution. Where an observer is present to make a daily precipitation reading, the water equivalent of freshly fallen snow is reported.

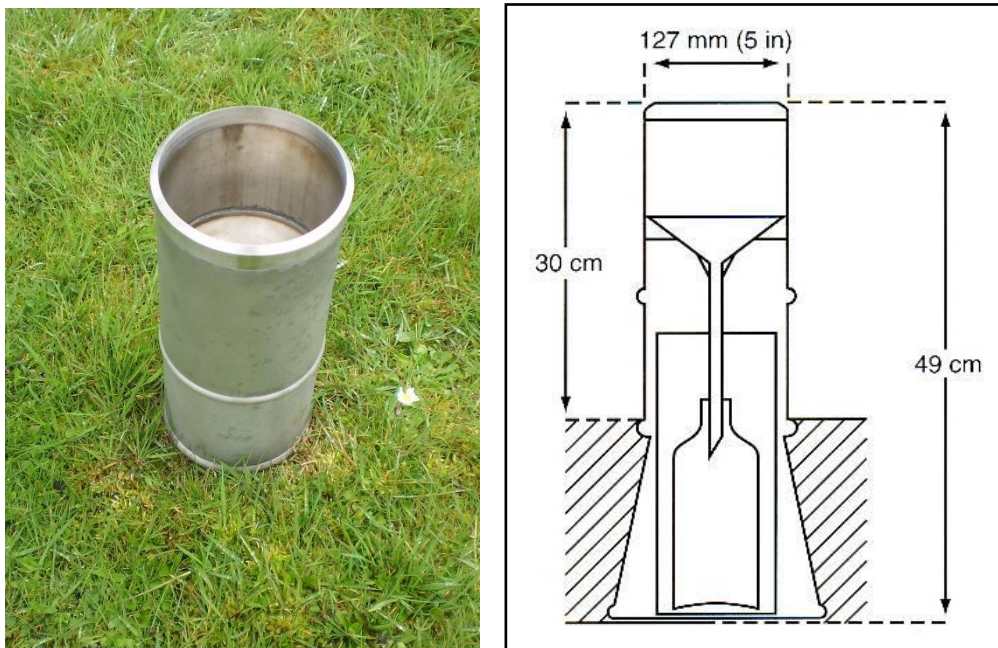


Figure 13. 5-inch rain-gauge

3.8.3 Tipping bucket raingauge

For many years the Met Office has used a tipping-bucket rain-gauge for the automatic measurement of rainfall rate (figure 14). The collecting funnel has a sampling area of 750 cm², the rim is set 450 mm above the surrounding ground level and a mechanism records an event each time a rainfall increment of 0.2 mm has been detected. A small container or bucket which, when filled with rain, tips and empties while recording the event electronically. The size of bucket used widely across the UK network holds 0.2 mm of rain. In the past bucket tip times were stored directly by a data logger (such as the Met Office SSER system in use since the early 1980s) or converted locally to a rainfall accumulation by systems such as SAMOS, ESAWS or CDL. At present MMS converts bucket tip times into a rainfall accumulation on a minute by minute basis then compiles and sends the hourly value in the SREW (Synoptic Rainfall Europe West) reports.



Figure 14: Tipping bucket raingauge

3.8.4 Other automatic raingauges

The (TSR) tilting siphon raingauge (no longer in use) produced an autographic record of rainfall accumulation from a pen attached to a float in the rainfall chamber of the instrument. The rainfall chart was analysed to give hourly accumulation as well as duration of precipitation where 0.1mm/hour was exceeded.

Some organisations also use weighing raingauges in their network and daily accumulations are sent to the Met Office for ingestion to MIDAS where available.

3.8.5 Rainfall accumulation periods and observing practices

Hourly accumulations

The earliest hourly accumulations of rainfall stored in MIDAS date back to 1949, but it was not until the 1960s that the network of stations reporting hourly began to increase. Some autographic rainfall records from before the war exist in the archives. In the past, hourly rainfall was reported by manual analysis of the autographic record from a TSR reported on a 7113 form for the period HH-60 to HH-0 or was derived from the tip times recorded on a SSER or CDL logger for the period HH-60 to HH-0

With the arrival of automation and TBRs across the network it is now common practice for a TBR to be used for both hourly SREWs and the NCMs. The hourly accumulation is for the period HH-70 to HH-10 and is reported in the SREW message. The MMS system uses this approach in almost every case. In the past, some stations will have had both a TBR and 5 inch gauge with one for the SREW and one for the NCM. Manned automatic stations may include a check gauge which is normally a 5 inch rain gauge but in a few cases is a TBR. These can be used to provide check readings for the primary rain gauge.

Other early rainfall measurement practices for hourly data are described in **appendix D**.

12-hourly accumulations

12-hourly accumulations of rainfall are contained in the National Climatological Message (NCM) which is sent in real time twice a day at 0900 and 2100 from most synoptic stations. NCMs have been in use since 1982 before which time daily climate readings were returned each month on 3259 forms. The NCM value is used for all climatological studies of rainfall on time scales of a day or more, and in the past the observation derived from the reference 5 inch gauge at the site. With the introduction of automated systems, as noted above, the TBR has become the reference gauge at automatic sites.

Daily accumulations

Daily accumulations are the starting point for climatological studies of rainfall. They will originate from:

- The sum of the two 12-hour accumulations contained in the NCM sent from synoptic stations
- Daily observations at climate stations using the 5 inch gauge
- Daily observations at rainfall stations using the 5 inch gauge (e.g. Daily accumulations from both SEPA and Environment Agency gauges are sent to the Met Office on a monthly basis and ingested into MIDAS.)
- Processing of data from loggers (e.g. SSER, CDL) to give 24-hour accumulations.

Manned sites also reported check readings, using the 5-inch gauge, until the mid-2000s. The check readings were stored in MIDAS as check gauge (i.e. not the primary gauge) but this practice ceased as the network became more automated. Check readings are no longer reported and are no longer stored in MIDAS. TBR gauges are regularly inspected and calibrated and prove to be very reliable.

From the earliest days of observing in the UK, the standard period for measuring daily rainfall has been 0900-0900 UTC.

Multiple-day accumulations

The current dense network of rainfall stations relies heavily on contributions from observers whose profession is not meteorology; they may work voluntarily or for an employer in a weather related field. There is no guarantee that observations will be taken every day and indeed an infrequent observing schedule may be agreed when a station opens. It is also possible that the observing time of 0900 UTC is not rigorously adhered to, particularly at remote sites or where several gauges are read by one observer. Many observed rainfall totals are valid for periods of more than one day; a reading may be taken at 0900 on Monday covering 3 days over the weekend, or at remote sites, it might cover a complete month. In each case, readings for multiple-day accumulations of rainfall should be taken at 0900UTC. All original values are stored in MIDAS with the day count set to the appropriate value. Some sites report on a monthly basis using a larger monthly storage raingauge.

3.8.6 Snowfall

Depth of fresh snow and depth of lying snow are reported daily at 0900UTC at synoptic and climate stations and hourly at synoptic stations when snow is lying. Such measurements should exclude the effects of drifting or blowing snow where possible. All reports of rainfall accumulation should include the liquid equivalent of any solid precipitation that has fallen in the period. At manned stations without automated sensors, snow depth is measured by the observer using a measuring rod at a number of representative locations.

Snow Depth Sensors

A snow depth sensor is an electrically-powered active device with on-board data-processing that measures the distance between the sensor and the ground surface beneath it. The distance can be measured using a laser based or ultrasonic device. Figure 15 shows an

ultrasonic device where a transducer transmits pulses and listens for the returning echoes from the surface. The measurement is made over an artificial grass having approximately the same thermal properties of a grass surface but which avoids spurious readings caused by the slow growth of grass



Figure 15. Snow depth sensor

In 2004-2006 a number of automatic weather stations were installed with snow depth sensors which were included in the SYNOP message if there was any snow. From 2012, a number of laser snow depth recorders were installed in the network.

3.8.7 Precipitation measurement - Sources of error

Potential errors in the measurement of precipitation include:

- Gross errors in the reading or the transcription of values at manual stations
- Errors in the time the observation was taken.
- Under recording by TBRs in heavy rain when precipitation can be missed during the period of tipping.
- The effects of snow blocking the raingauge.
- Malfunctioning instrument. A TBR may “double bounce”, that is produce a spurious rainfall tip event just after a genuine one. The MMS system checks for this and removes any tips which appear to be “bounce tips” from the 1 minute record and subsequent hourly values.
- Insects and animals may be a problem at unmanned sites.
- Poor exposure of the gauge. Trees may have overgrown, or the site may be excessively exposed in strong winds.
- Loss of rain water due to evaporation
- Automatic snow depth sensor malfunction
- Snow depth sensor measurements may be affected by animals etc

Errors that used to occur in equipment no longer used:

- TSR float chambers could freeze in cold weather.
- Under recording by TSRs in moderate to heavy rain during the period of siphoning.

3.9 Radiation and sunshine

3.9.1 Overview

Four different components of radiation in the atmosphere are measured routinely at some synoptic land stations:

- Global radiation – total downwelling short-wave radiation (visible wavelengths to 4 μm), measured on a horizontal surface;
- Diffuse radiation – global radiation minus the direct component from the sun, also measured on a horizontal surface;
- Direct radiation – radiation coming from the sun and not the rest of the sky, measured at normal incidence;
- Long wave radiation – downwelling infra-red wavelengths from 4 μm upwards.

Global radiation is measured by a pyranometer (figure 16). Measurement of the diffuse components requires a tracking device that ensures that the sun is obscured by a ring or a tracking shading device (figure 17) and is only undertaken at a few principal radiation stations. All instruments operate by directing incoming radiation onto the black-painted upper surface of a thermopile. This generates a temperature gradient across the thermopile which in turn produces a voltage proportional to the intensity of the radiation.

The correct exposure of any radiation or sunshine instrument at the observing site is very important. Ideally the horizon should be level in all directions, although the poleward arc is less important for sunshine and direct radiation measurements. In practice this is rarely the case and sites need to be assessed and graded according to the distribution of obstacles around the horizon.

All instruments are calibrated by reference to absolute cavity radiometers, standard radiation instruments that are maintained by the Met Office. These standards are precision pyrhemeters incorporating an electrical heater on the sensing element, the input of which can be measured very accurately. Inter-comparisons made at Davos Switzerland ensure traceability to the world radiation standard.

Radiation is reported in MIDAS as either global, direct or diffuse in kJ m^{-2} to the nearest whole kJ. When radiation measurement began back in 1947 all three types were recorded and stored on MODLE (Met Office Data Logging Equipment) every hour and DRADR35 every day. This carried on until the end of 2006 when radiation measurements became automated.

3.9.2 Kipp and Zonen Pyranometer

This instrument was first introduced at Met Office sites in 1993 (figure 16). The instrument has a thermopile detector with a glass dome above it with an aluminium housing. The thermopile is coated with black absorbent paint. The absorbed radiation is converted into heat which flows through thermal resistance of the thermopile to the heat-sink. The temperature difference across the thermal detector is then converted into a voltage. This is stored in W/m^2 and is calculated based on the average value over the previous minute based on 2 second samples. When this data is transferred into MIDAS the reading is converted into kJ m^{-2} . These readings are taken on an hourly basis.

3.9.3 Sunshine

For a great many years the only instrument for measuring sunshine duration was the Campbell-Stokes sunshine recorder (figure 19). The original instrument was invented by

Campbell in 1858 but the later card-holding version was a development by Stokes in 1879. Most of the climate record was collected using this instrument and is in use today at non-automated climate stations. A glass sphere focuses the sun's direct radiation on a graduated card and the length of the burn trace on the card corresponds to the duration of sunshine. This method of measurement overestimates sunshine duration on days when the sun is frequently shaded by passing clouds. At many automated stations a modern sunshine sensor is used in its place (figure 18). It uses an array of differently exposed photodiodes to estimate the intensity of direct radiation. A threshold intensity of 120 Wm^{-2} defines the occurrence of full sunshine. When this value is exceeded for that minute it is given a 1. Therefore if there have been 12 sunshine minutes from 0851-0950 then the 1000 hourly value would be $12/60 = 0.2$ which is stored in MIDAS in the weather drnI_table. The value given in MIDAS is an hourly reading of the number of sunshine hours between 0 and 1, 0 being no sunshine and 1 being a full hour of sunshine.



Figure 16. Pyranometer for measuring global radiation



Figure 17. Tracking pyranometer



Figure 18. Sunshine duration meter



Figure 19. Campbell-Stokes sunshine recorder

3.9.4 Derived sunshine duration

With the introduction of MMS and the availability of minute data in a central database it has become possible to obtain a derived sunshine duration value from the global radiation value stored in the MMS. The derived value is calculated using the minute global radiation value. A formula is applied to this value to determine whether the minute is 'sunshine' and this is

stored in MMS as a '1' (see appendix A). This enables an hourly value to be calculated by summing the number of values in the hour and dividing them by 60. These are then added together to give a daily value which is stored in MIDAS in the weather_drnl_ob table under the column DRV_HR_SUN_DUR. It is important to remember that WMO sunshine and Derived sunshine are different and should not be regarded as equivalent values.

3.9.5 Sources of error

- Where a manual shade ring is employed on the diffuse sensor, this might suffer from incorrect setting, particularly when there has been a lack of sunshine for several days, therefore producing little or no shadow to guide the Observer.
- Moisture in the sensor
- Dirt, snow, or frost on the dome of the sensor.
- Poor exposure
- Campbell stokes sunshine recorders can over record on days of broken cloud. A short burst of bright sunshine can give a burn representing at least 0.1 hour while several of these in quick succession will appear as a continuous burn.

3.10 Visibility

3.10.1 Overview

Visibility is reported in metres or kilometres and is stored in MIDAS in decametres. In the SYNOP message a code is used giving a resolution of 30m (30m to 100 m); 100m (100 m to 5 km); 1km (5 km to 30 km) and 5 km (30 km to 70 km). There is a further coarser reporting code for use where there are few visual reference points which are principally used at sea.

For a great many years meteorological visibility was estimated by the human observer judging the appearance of distant objects against a contrasting background, usually the sky. Various rules have been established for how visibility should be judged:

- An object should not merely be seen but should be identifiable against the background as a specific object;
- Visibility should be estimated at ground level where there is an uninterrupted view of the horizon;
- If the visibility varies from one direction to another, the lowest value should be reported;
- For the purposes of aviation the prevailing visibility should be reported.

Hand-held Gold visibility meters were available for many years to aid the estimation of visibility, but from the 1990s visimeters were widely installed at stations in the synoptic network.

Today, most synoptic observing stations have sensors which provide a measurement of visibility where the station operates in fully automatic mode. At the smaller number of stations where there is still a human observer (e.g. at airfields) the sensor acts as an aid in the estimation of visibility. Visibility sensors measure the meteorological optical range which is defined as the length of atmosphere over which a beam of light travels before its luminous flux is reduced to 5% of its original value. In most instances this is approximately equivalent to, but not the same as, visibility measured by the contrast of a distant object against its background. A typical visibility sensor used at synoptic observing stations is shown in figure 20. It applies the forward scattering characteristics of light to measure the extinction coefficient of a beam generated by a high intensity xenon strobe transmitter directed at a

volume of air close to the sensor. Reasonably accurate measurements are possible over a range of visibility extending from a few tens of metres to a few tens of kilometres.



Figure 20: Visibility sensor

Vertical visibility may be reported from airfields in the SYNOP and METAR messages to a resolution of 100ft. It is measured when the sky is obscured and the horizontal visibility tends to be very low. It is a visual measurement for which a nearby object of known height (and intermediate points of known or estimable height) may still be visible. This is stored in the `weather_hrly_ob` table in MIDAS.

Runway visual range (RVR) may be reported from airfields in the METAR message. It is defined as the maximum distance in the direction of take-off or landing at which the runway, or specified lights or markers along the runway, can be seen from a point above its centre line. The height of this point is taken to be 5m above ground level, corresponding to the average eye-level of pilots at touchdown. This is stored in the `runway_ob` table in MIDAS. More than one RVR may be reported at airfields with more than one runway,

3.10.2 Visibility measurement - Sources of error

- The visiometer can be adversely affected by dirt or spiders webs
- The visibility from a visiometer is local to the site and so may be different to manual observations which take into account the lowest visibility in the entire horizon.
- Some visibility sensors have limits on the range reported and some tend to under-report at the higher visibility ranges.

3.11 Present and past weather

3.11.1 Present weather observations

Definitions for the internationally agreed codes for present weather may be found at <http://www.wmo.int/pages/prog/www/WMOCodes.html>. Two code forms for present weather are defined, one for use by the human observer and one for automatic instruments.

Present weather may be summarised as falling into a number of different categories:

- Showery precipitation with thunderstorm
- Showery precipitation without thunderstorm
- Frozen precipitation
- Freezing rain or sleet
- Rain
- Rain and drizzle
- Drizzle
- Fog or ice fog
- Duststorm, sandstorm, drifting or blowing snow
- Precipitation, fog, ice fog or thunderstorm at the station during the preceding hour but not at the time of observation
- Other meteorological phenomena

In the past the recording of present weather was heavily based on a human observation, but since 2001, present weather sensors have been used widely in the synoptic surface network and are shown in figures 21 and 22. One is essentially a forward scattering visibility sensor and the other a sensor for detecting the presence of recent precipitation. Output from these two instruments together with measurements of air temperature, relative humidity and rainfall rate are analysed to derive the present weather code that best fits the data. The measurement of present weather is difficult to automate with the result that the human observer where present at the station may need to correct the reported value. Past weather codes define the dominant weather during the preceding hour, 3 hours or 6 hours.

A weather group is reported only when there is or has been significant present or past weather during the period covered by the observation. Where there is no significant weather to report, the group is omitted and there is a null or missing data indicator in the hourly report in MIDAS.



Figure 21. Present weather sensor

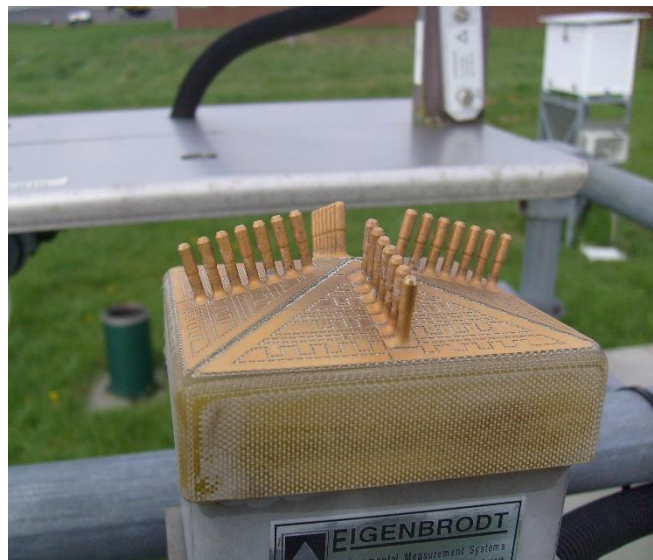


Figure 22. Precipitation detector

3.11.2 Present weather measurement - Sources of error

- Present weather can be missed, such as rain showers by-passing the station.
- Dirt on the sensor can lead to errors in the codes reported.
- Differences in sampling periods between the sensors can lead to apparent mis-reporting of weather, for example, fog with visibilities greater than 1000 metres.

3.12 Clouds

3.12.1 Overview

Cloud height is one of the remaining meteorological parameters still measured in the imperial units. It is reported in code form for each of the cloud groups in the SYNOP message to a resolution of 100ft (100ft to 5000ft), 1000ft (5000ft to 30000ft) and 5000ft (above 30000ft). Heights are converted to decametres (dam) for storage in MIDAS. Cloud amount has been measured in eighths since 1949. Cloud amounts before 1949 were measured in tenths but have been converted to eighths for storage in MIDAS. The J-descriptor for the observation indicates the observation units and the sign of the rounding error where a conversion has taken place. In this way the original value as observed may be recovered.

3.12.2 Cloud Observations

The standard method for classifying clouds is based on World Meteorological Organisation criteria (see WMO Manual on Codes. No. 306). The classification is made in terms of the level of the cloud (high, medium or low) and various cloud genera specified by the cloud form and its features. Common types of cloud include cumulus, cumulonimbus, stratocumulus and stratus at low levels; altocumulus, nimbostratus and altostratus at medium levels and cirrus, cirrocumulus and cirrostratus at high levels. As there are no

automated systems for the detection of cloud type, its reporting is only possible where the human observer is present.

At any time, different types of cloud at different heights above the ground may be visible from an observing station. To cater for such variability, both the total cloud amount and partial cloud amounts are reported. Total cloud amount is the fraction of the sky covered by cloud of any type or height above the ground. Partial cloud amount is the fraction of the sky covered by each type or layer of cloud as if it was the only type or layer of cloud in the sky. Cloud amount is reported in oktas or eighths with the additional convention that:

- Zero oktas represents the complete absence of cloud;
- 1 okta represents a cloud amount of 1 eighth or less, but not zero;
- 7 oktas represents a cloud amount of 7 eighths or more, but not full cloud cover;
- 8 oktas represents full cloud cover with no breaks;
- 9 oktas represents sky obscured by fog or other meteorological phenomena.

A cloud base recorder can be used to estimate partial cloud amount. For each layer of cloud identified by the instrument a time weighted average is used to derive the average amount. Such measurements are by their nature only representative of the cloud that has passed directly above the instrument, not of the total sky that is on view from the station.

Cloud base is readily measured by instruments to a reasonable level of accuracy. An example of a cloud base recorder used at synoptic observing stations is shown in figure 23. It employs a pulsed diode laser LIDAR (light detection and ranging) technology whereby short laser pulses are sent out in a vertical or near vertical direction. The backscatter caused by reflection from the surface of cloud, precipitation or other particles is analysed to determine the height of the cloud base.



Figure 23: Laser cloud base recorder

Manual observation of cloud height may be purely visual or be made with the assistance of measuring devices. In the past, pilot balloons, with a lantern attached at night, could be

timed to the point of entry into the cloud, and reports from aircraft are a valuable additional source of information at airfields. At some stations, especially airfield sites, cloud searchlights were used at night. These throw a spot of light on the base of the cloud at a height which can be measured by triangulation.

At the beginning of 2000, some SAMOS stations began to automatically provide measurements of cloud height from a Laser Cloud Base Recorder (LCBR). Currently the majority of stations which produce SYNOP observations have an LCBR to make automatic observations when the station is not manned.

3.12.3 Cloud observations – Potential sources of error

- Data recorded is only that directly above the LCBR.
- Weather can affect the LCBR readings. E.g. Snow can obscure the laser.
- Dirt can also obscure the lens of the laser.

3.13 State of ground observations

At manned observing sites a 'state of ground' report may be provided. Within the observing site enclosure is an area of bare soil, ideally around 2m square, which is kept free from weeds and not dug over. Its surface should be flat and level with the surrounding ground and ideally at least the top 15 cm of soil should be representative of the whole site. The state of ground is reported using a code figure. See tables below.

State of ground WITHOUT snow or measurable ice cover	Code
Surface of ground dry (without cracks and no appreciable amount of dust or loose sand).	0
Surface of ground moist.	1
Surface of ground wet (standing water in small or large pools on the surface).	2
Flooded.	3
Surface of ground frozen.	4
Glaze on the ground.	5
Thin layer of loose, dry dust or sand, not covering ground completely.	6
Thin layer of loose, dry dust or sand, covering ground completely.	7
Moderate or thick layer of loose, dry dust or sand, covering ground completely.	8
Extremely dry with cracks.	9
Covered by snow or measurable ice cover or cannot be described by one of the above.	/

State of ground WITH snow or measurable ice cover	Code
Ground predominantly covered by ice.	0
Compact or wet snow (with or without ice), covering less than one-half of the ground.	1
Compact or wet snow (with or without ice), covering at least one-half of the ground, but the ground not completely covered.	2
Even layer of compact or wet snow, covering the ground completely.	3
Uneven layer of compact or wet snow, covering the ground completely.	4
Loose, dry snow, covering less than one-half of the ground.	5
Loose, dry snow, covering at least one-half of the ground (but not completely).	6
Even layer of loose, dry snow, covering the ground completely.	7
Uneven layer of loose, dry snow, covering the ground completely.	8
Snow covering the ground completely; deep drifts.	9
Not covered by snow or measurable ice cover or cannot be described by one of the above.	/

3.14 'Days of' observations

At manned observing sites if hail, thunder, fog, a gale or snow occurs in the period 0000 hours to 2400 hours, then this may be reported in the NCM or, in the case of voluntary climate observers, the form 3208 report. See tables below.

S ₁ /S ₂ /S ₃ /S ₄	Depth of snow	Table 18	E ₁	State of concrete	Table 22	H	Day of hail, ice, etc.	Table 23	S	Day of snow or sleet	Table 27
Code figure	cm		Code figure			Code figure			Code figure		
001	1		0	Slab dry		0	No hail, ice, etc. (0000-2400 GMT)		0	No snow or sleet (0000-2400 GMT)	
002	2		1	Slab moist		1	Diamond dust		1	Sleet	
...	...		2	Slab wet		2	Snow grains		5	Snow	
996	996		3	Slab icy		3	Snow pellets		9	No snow or sleet (restricted period)	
997	Less than 1/2 cm		/	Slab covered by snow or slab not adequately described by code figures 0 to 3		4	Ice pellets or small hail (less than 5 mm diameter)		/	Unobservable due to office being unmanned throughout the observing period	
998	Snow cover, not continuous					5	Hail (diameter 5-9 mm)		Note:	When sleet and snow are observed on the same day the entry is 5. Entries are to be made even when the fall yields no measurable amount in the rain-gauge.	
999	Measurement impossible or inaccurate					6	Hail (diameter 10-19 mm)				
						7	Hail (diameter 20 mm or more)				
						9	No hail, ice, etc. (restricted period)				
						/	Unobservable due to office being unmanned throughout the observing period				
T	Day of thunder	Table 24	F	Day of fog	Table 25	G	Day of gale	Table 26		Note:	In Tables 23, 24, 26 and 27 code figure 9 is used to indicate those days when a phenomenon is known not to have occurred during a period of restricted weather watch of less than 0000-2400 GMT (but may or may not have occurred outside the period of restricted watch).
Code figure			Code figure			Code figure					
0	No thunderstorm (0000-2400 GMT)		0	Visibility 1000 m or more at 0900 GMT (previous day)		0	No gale (0000-2400) GMT				
1	Thunderstorm, with or without precipitation		1	Visibility less than 1000 m at 0900 GMT		1	Day on which the wind speed has reached a 34 knot mean (Beaufort force 8) for a period of at least 10 minutes				
9	No thunderstorm (restricted period)					9	No gale (restricted period)				
/	Unobservable due to office being unmanned throughout the observing period										

Due to the increase in automation of the observing networks, the 'days of' reports have become more sparse. To meet the needs of the data users, derived 'days of' reports are now populated in MIDAS for gales, snow and hail using measurements obtained from the automatic weather sensors at the site. It selects any hourly automatic present weather reports of snow, sleet or hail and hourly/10 minute mean wind speeds > 33 knots and inputs the relevant code figure into the weather_drnl_ob_table. The quality control flag 1001 is also set on the data to indicate that the observation is an estimate derived automatically (see section 5 for further details on quality control flags). The table below gives further details of the methodology.

Days of snow	
snow_day_id	Present weather code
1	67 or 68 reported in at least one hourly observation
5	24, 70, 71, 72, 73, 85, 86, 87 reported in at least one hourly observation
9	None of the above and at least 1 present weather observation unavailable in past 24 hrs.
0	None of the above and all observations available.
Days of gale	
gale_day_flag	Hourly wind observations
1	At least one hourly or 10 minute mean wind speed > 33 knots
0	No wind speed observations > 33 knots and 24 observations received
9	No wind speed observations > 33 knots and at least one wind observations unavailable in past 24 hrs
Days of hail	
hail_day_id	Present weather code
2	77 reported in at least one hourly observation
3	74, 75, 76 reported in at least one hourly observation
4	89, 93, 96 reported in at least one hourly observation
9	None of the above and at least 1 present weather observation unavailable in past 24 hrs
0	None of the above and all observations available.

Obviously these automated reports are limited by the accuracy of the automated sensor, but even manual reports are fairly subjective due to the fact that a 24 hour watch on the weather is required, which is rarely possible.

3.15 Calibration, maintenance and inspection

Most measurements are made with full traceability to national or international standards; in other words, it can be demonstrated that a series of calibrations have been performed which link the instrument used for the measurement to some national or international standard instrument. This practice, which for temperature and pressure has been unbroken since the 1850's, ensures a uniformity of measurement over time. Instruments are calibrated after receipt from the manufacturer and in some cases at intervals after that. Some of the other checks performed to ensure a properly functioning observing system are as follows:

- Observers perform basic routine checks of equipment quality as part of normal observing practice.
- Observations and the observing practice are checked.
- Observations are monitored routinely on receipt and engineers are called out where faults occur.
- Regular maintenance is performed on all instrumentation.
- Regular inspections of all surface land stations are carried out. Checks are made of equipment, exposure and observing practice. Check readings are taken.
- Quality control is performed on most land observations data in MIDAS (See section 5).

3.16 Sources of metadata

The term metadata, as applied to observations, is taken to mean those data which describe the contents of the climate archive and which allow the user to understand the origins of the meteorological values themselves. They describe the characteristics of the observational networks and typically include details about the station, its location, environment and observing programme as well as information about the instruments, their relative locations and exposure at present and at times in the past. Observational metadata for UK stations have been built up over the years from several sources. Most station metadata are now available through the MIDAS database and are stored on the METADATA schema. There are however many items of historical metadata which have not been digitised and stored in the METADATA schema. If any data cannot be found there, it may be available from:

- Paper records stored in the Met Office archive.
- Electronically stored records (the station folders) maintained by the Met Office Land Observations Networks team.

4. MIDAS Tables

This chapter provides information on how the various land based observations are stored in MIDAS.

4.1 Message and report types

The following sections list the parameters contained in various messages and reports. All elements are not reported from every station. The MIDAS handbook provides details on the MIDAS tables and the structure and use of the database.

4.1.1 SYNOP

The SYNOP is an internationally agreed coded message format, also referred to as FM-12 in WMO documentation. It has been in use since the 1940s and is used for real time transmission of synoptic weather observations. It is currently used by all Met Office AWS sites to send hourly observations, which are stored in MIDAS. SYNOP reports are also received from international sites. For all UK sites, the time of observation is HH-10.

The following elements from SYNOP messages are stored in MIDAS for Met Office sites. The code tables refer to the WMO manual on codes, No. 306.

DESCRIPTION	UNITS	DETAILS	MIDAS TABLE/COLUMN
source operation type	1 digit code	Type of station operation (manned or automatic). Reported using WMO code table 1860	weather_hrly_ob/ src_opr_type
height of lowest cloud	dm	Reported using WMO code table 1600 which renders the cloud base height as a 1 digit code.	weather_hrly_ob/ cld_base_ht
Visibility	dm	Horizontal visibility. Reported using WMO code table 4377 which renders the visibility as a 2-digit code.	weather_hrly_ob/ visibility
total Cloud Cover	oktas	Reported using WMO code table 2700	weather_hrly_ob/ cld_ttl_amt_id
wind Speed	knots	Mean speed of wind over 10 minutes preceding observation time. Reported in whole knots.	weather_hrly_ob/ wind_speed
wind Direction	degrees from true north	Mean direction of wind over 10 minutes preceding observation time. Reported in 10 of degrees.	weather_hrly_ob/ wind_direction
air temperature	degrees Celsius	Reported in tenths of degrees.	weather_hrly_ob/ air_temperature
dewpoint temperature	degrees Celsius	Reported in tenths of degrees.	weather_hrly_ob/ dewpoint
"as read" station pressure	hPa	Reported in tenths hPa. (Only until September 1999 at high level stations.)	weather_hrly_ob/ stn_pres
mean sea level pressure	hPa	Reported in tenths hPa	weather_hrly_ob/ msl_pressure
present weather	2 digit code	Reported using WMO code table 4677	weather_hrly_ob/ prst_wx_id
past weather 1	1 digit code	Reported using WMO code table 4561.	weather_hrly_ob/ past_wx_id_1
past weather 2	1 digit code	Reported using WMO code table 4561.	weather_hrly_ob/ past_wx_id_2
state of ground	2 digit code	Reported using WMO code table 0901 (without snow cover) or 0975 (with snow cover). A leading 0 indicates no snow cover and a leading 1 indicates snow cover. Only available at manned sites.	weather_hrly_ob/ ground_state_id
snow depth	cm	Reported in whole cm	weather_hrly_ob/ snow_depth
hourly WMO sunshine	hours	Reported in tenths of hours. Available at a few non-standard sites from 1996 and more widely from 2000.	weather_hrly_ob/ wmo_hr_sun_dur
hourly Campbell-	hours	Reported in tenths of hours. This element has not been reported at	weather_hrly_ob/ cs_hr_sun_dur

Stokes sunshine		any Met Office sites since 2004 - WMO sunshine superseded this element.	
24 hour WMO sunshine	hours	Reported in tenths of hours. Available at a few non-standard sites from 1996 and more widely from 2000.	weather_drnl_ob/wmo_24hr_sun_dur
24 hour Campbell-Stokes sunshine	hours	Reported in tenths of hours. This element has not been reported at any Met Office sites since 2004 - WMO sunshine superseded this element.	weather_drnl_ob/cs_24hr_sun_dur
cloud layer amount	oktas	Reported using WMO code table 2700	weather_hrly_ob/cld_amt_id_i where i = 1 to 4
cloud layer height	dm	Reported using WMO code table 1677	weather_hrly_ob/cld_base_ht_id_i where i = 1 to 4
cloud layer type	1 digit code	Reported using WMO code table 0500. Only available from manned sites.	weather_hrly_ob/cloud_type_id_i where i = 1 to 4
maximum gust speed	knots	Maximum gust speed over 10 minutes preceding observation time. Reported using WMO code table 3778.	weather_hrly_ob/q10mnt_mxgst_spd

Relative humidity and wet bulb temperature, which are also stored in the weather_hrly_ob table, are derived from the air temperature and dewpoint temperature values by an internal MIDAS procedure - they are not reported directly in SYNOP messages.

Pressure tendency, maximum and minimum air temperature, 0600 grass minimum temperature and precipitation are also reported using the SYNOP message but these parameters are not stored in MIDAS for Met Office sites. Pressure tendency can be derived from the hourly pressure values if required. Temperature maxima and minima in MIDAS are taken from the NCM and precipitation data from the SREW and NCM reports (see below). Phenomena reported using “special” groups in the SYNOP message are not stored in MIDAS.

SYNOP data are available for all Met Office synoptic sites. SYNOP data are also available from Met Office CDL (Climate Data Logger) sites, usually with a reduced number of available parameters compared to full synoptic sites. These sites’ data are stored using a met_domain_name value of AWSHRLY and a DCNN (not WMO) ID. (see later in section 4 for more details)

4.1.2 SREW

The real time exchange of hourly rainfall accumulations between European countries is achieved using the SREW message format (Synoptic Rainfall Europe West). As for SYNOPs, the UK practice regards the observation period as ending at HH-10, therefore the reported rainfall is for the period HH-70 to HH-10. Accumulations are reported to the nearest 0.2 mm and there is an indicator for trace.

DESCRIPTION	UNITS	DETAILS	MIDAS TABLE/COLUMN
-------------	-------	---------	--------------------

Hourly rainfall	mm	Rainfall total over one hour preceding the observation time	rain_hrly_ob/ prcp_amt
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4.1.3 METAR

Synoptic observations for aviation purposes use the METAR code. Hourly reports are stored in MIDAS.

The following from the METAR message are stored in MIDAS. The WMO manual on codes No.306 gives more details on how the elements are reported:

DESCRIPTION	UNITS	DETAILS	MIDAS TABLE/COLUMN
Altimeter pressure (QNH)	hPa	Reported in tenths hPa.	weather_hrly_ob/ alt_press
Air temperature	Degrees Celsius	Reported in whole number degrees.	weather_hrly_ob/ air_temperature
Dew point	Degrees Celsius	Reported in whole number degrees.	weather_hrly_ob/ dewpoint
Wind speed	Knot	Mean speed of wind over 10 minutes preceding observation time. Reported in whole knots.	weather_hrly_ob/ wind_speed
Wind direction	degrees from true north	Mean direction of wind over 10 minutes preceding observation time. Reported in 10s of degrees.	weather_hrly_ob/ wind_direction
Visibility	dm	Horizontal visibility. Reported in whole decametres.	weather_hrly_ob/ visibility
Vertical visibility	dm	Stored in whole decametres.	weather_hrly_ob/ vert_vsby
Runway visual range	m	Stored in metres.	runway_ob/ rnwy_vis_rnge
Cloud amount	Oktas	Stored as 1, 3, 6 or 8 oktas in MIDAS corresponding with Few, Scattered, Broken and Overcast from the METAR code.	weather_hrly_ob/ cld_amt_id_1(2,3,4)
Cloud base height	dm	Reported in whole decametres	weather_hrly_ob/ cld_base_ht_id_1(2,3,4)
Maximum gust speed	knot	Maximum gust speed over 10 minutes preceding observation time. Reported in whole knots when gust speed exceeds mean speed by 10kt or more	weather_hrly_ob/ q10mnt_mxgst_spd

4.1.4 HCM

Hourly Climate Messages (HCM), produced from automated systems, mainly MMS, are transmitted in real time in the same way as SYNOPs and SREWs, and like those observations the HCM covers the period HH-70 to HH-10.

The following from the HCM message are stored in MIDAS.

DESCRIPTION	UNITS	DETAILS	MIDAS TABLE/COLUMN
Mean hourly wind direction	degrees from true north	Mean hourly wind direction over preceding hour.	wind_mean_ob/ mean_wind_dir
Mean hourly wind speed	knot	Mean hourly wind speed over preceding hour.	wind_mean_ob/ mean_wind_speed
Direction of maximum gust	degrees from true north	Direction of maximum gust over preceding hour.	wind_mean_ob/ max_gust_dir
Speed of maximum gust	knot	Speed of maximum gust over preceding hour.	wind_mean_ob/ max_gust_speed
Time of maximum gust	HHmm	Time of maximum gust over preceding hour to nearest minute.	wind_mean_ob/ max_gust_ctime
10 cm soil temperature	0.1C	Hourly 10cm soil temperature.	soil_temp_ob/ q10cm_soil_temp
Global radiation	W hr/m ²	Total global radiation over preceding hour	radt_ob/ glbl_irad_amt

4.1.5 NCM

National Climate Messages (NCM) are transmitted in the same way as SYNOPs and SREWs. A full message is sent at the nominal time of 0900 UTC each day and most stations also send an abbreviated message at 2100 UTC. Note that, as for SYNOP and SREW, the periods of the observations start and end at 10 minutes to the main hour, i.e. 0850 and 2050 UTC.

The following from the NCM message are stored in MIDAS. All times are UTC.

DESCRIPTION	UNITS	DETAILS	MIDAS TABLE/COLUMN
Grass minimum temperature	degrees Celsius	0900-0900 or 1800-0900 or one hour before sunset to 0900, depending on local practice	temp_drnl_ob/ min_grss_temp
Concrete minimum temperature	degrees Celsius	0900-0900 or 1800-0900 or one hour before sunset to 0900, depending on local practice	temp_drnl_ob/ min_conc_temp
State of ground	Code	See SYNOP table.	weather_hrly_ob/ ground_state_id
State of concrete slab	Code	At 0900	weather_drnl_ob/ conc_state_id
Maximum temperature	degrees Celsius	0900-2100 & 2100-0900	temp_drnl_ob/ max_air_temp
Minimum temperature	degrees Celsius	0900-2100 & 2100-0900	temp_drnl_ob/ min_air_temp
Rainfall accumulation	mm	0900-2100 & 2100-0900, or 0900-0900	rain_hrly_ob/ prcp_amt rain_drnl_ob/ prcp_amt
Soil temperature	degrees Celsius	At 10cm, 30 cm and 100 cm. At 0900	soil_temp_ob/ q10cm_soil_temp q30cm_soil_temp

			q100cm_soil_temp
Days of hail, thunder, gale, snow	Code	Reported at 0900 for previous 00-24 day.	weather_drnl_ob/ hail_day_id thunder_day_id gale_day_id snow_day_id
Depth of snow	cm	At 0900	weather_drnl_ob/ snow_depth
Depth of fresh snow	cm	0900-0900	weather_drnl_ob/ frsh_snw_amt

4.1.6 Daily climate

Climate stations normally make one observation a day, though over the years practices have changed and twice or three times a day observing was more common than it is today. Up until 2007 the paper form, covering a month's observations, was the usual method of recording the observation along with an electronic spreadsheet. In 2007 a new online observing web page called OWL (Observer Weather Log) was rolled out and allowed observers to submit their observation online on a daily basis. In 2012 this facility was replaced by WOW (Weather Observations Website) which was developed for the general public. Some voluntary observers still use Met Form 3208b to submit their observations. The observation time at most stations is 0900UTC, though a few observe at other hours. All data are archived for 0900UTC with no deviation allowed.

The following from Metform 3208b and WOW are stored in MIDAS. All times are UTC:

DESCRIPTION	UNITS	DETAILS	MIDAS TABLE/COLUMN
Cloud amount	Oktas or eighths	At 0900. 9 = sky obscured	weather_hrly_ob/ cld_ttl_amt_id
Wind direction	Degrees from true north	At 0900	weather_hrly_ob/ wind_direction
Wind speed	knot	At 0900	weather_hrly_ob/ wind_speed
Present weather	Code	At 0900	weather_hrly_ob/ prst_wx_id_1
Visibility	dm	At 0900	weather_hrly_ob/ visibility
Air temperature	degrees Celsius	At 0900	weather_hrly_ob/ air_temperature
Dew point	degrees Celsius	At 0900	weather_hrly_ob/ dewpoint
Minimum temperature	degrees Celsius	0900-0900	temp_drnl_ob/ min_air_temp
Maximum temperature	degrees Celsius	0900-0900	temp_drnl_ob/ max_air_temp
Grass minimum temperature	degrees Celsius	Usually 0900-0900, but may be 1 hour before sunset to 0900, depending on local practice	temp_drnl_ob/ min_grss_temp
Concrete minimum temperature	degrees Celsius	Usually 0900-0900, but may be 1 hour before sunset to 0900, depending on local practice	temp_drnl_ob/ min_conc_temp
Soil temperature	degrees Celsius	At 5, 10, 20, 30, 50 100 cm. At 0900	soil_temp_ob/ q5cm_soil_temp

			q10cm_soil_temp q20cm_soil_temp q30cm_soil_temp q50cm_soil_temp q100cm_soil_temp
State of ground	Code	At 0900	weather_hrly_ob ground_state_id
Depth of snow	cm	At 0900	weather_drnl_ob/ snow_depth
Rainfall accumulation	mm	0900-0900	rain_drnl_ob/ prcp_amt
Sunshine	hours	0000-2400	weather_drnl_ob/ cs_24hr_sun_dur
Days of snow, hail, thunder, gale	Code	0000-2400. Note: though reported most climate stations do not keep a 24 hour watch.	weather_drnl_ob/ hail_day_id thunder_day_id gale_day_id snow_day_id

Where a daily observation or a sequence of daily observations are missing, for example because the observer is unavailable or the station is not manned 7 days a week, the rainfall accumulation for the first day after the break will represent a multi-day total; similarly the maximum and minimum values may represent extremes over several days. The correct interpretation of the readings will be made clear on the form and stored in MIDAS, where appropriate, with a day count greater than 1. Note: all Max and Min temps are stored as 24 hours values in MIDAS.

On the Metform 3208b each line represents the observation for the given day; values of rainfall, maximum temperature and sunshine are “thrown back” to the previous day, in the sense that, for example, the 24 hour accumulation of rainfall read at 0900 on the 10th is entered on the 9th because it is assumed that most of the rain fell on that day. This practice does not affect the way the data are stored in MIDAS as the database indicates the observation period by the two parameters: observation end time and hour count. On WOW all observations are entered on the day that they are read. These observations are automatically thrown back when stored in MIDAS.

There were a great many different form types that preceded the 3208b, each allowing for the different observing practices that were in place at the time.

Stations of the rainfall network, for which rainfall accumulation is the only observation produced, return daily amounts on rain cards (Met Forms 7133, 7135). Where observations are made less frequently than once a day, multi-day accumulations are marked on the card and stored in MIDAS with a day count greater than 1. Many stations are operated by the Environment Agency (in England), and by SEPA (in Scotland), who send data to the Met Office electronically on a monthly basis.

4.1.7 Derived parameters in MIDAS

Some parameters in MIDAS are derived from the elements reported in the observation messages. These are shown in the table below.

DESCRIPTION	UNITS	DETAILS	MIDAS TABLE/COLUMN
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Relative humidity	%	Hourly from synoptic sites. At 0900 from daily climate sites - not reported on form 3208, but derived from air temperature and dew point temperature.	weather_hrly_ob/ rltv_hum
Wet bulb temperature	degrees Celsius	Hourly from synoptic sites. At 0900 from daily climate sites - not reported on form 3208, but derived from air temperature and dew point temperature.	weather_hrly_ob/ wetb_temp
Lying snow flag	Code	Derived from 0900 NCM state of ground report. If the state of ground with snow has more than half cover then the site is deemed to have a day of lying snow.	weather_hrly_ob/ lying_snow_flag
Derived sunshine duration	hours	See section 3.9.4	weather_drnl_ob/ drv_hr_sun_dur
Day of gale (at automatic sites)	Code	Derived from 10 minute or hourly mean wind speeds of 34 knots or more. Available from February 2011.	weather_drnl_ob/ gale_day_id
Day of snow (at automatic sites)	Code	Derived from automatic present weather reports of 68 & 69 (sleet) and 71-78 , 85-86 (snow). Available from October 2010.	weather_drnl_ob/ snow_day_id

4.1.8 Height of lying snow reports

The height (above mean sea level) of lying snow was assessed manually at a number of sites between 1946 and 2007. The data was sent on snow survey postcards and was not ingested to MIDAS at the time. This data was later digitised as part of a PhD project and was ingested to MIDAS in 2013 into the weather_drnl_ob table. The height of the lowest lying snow within sight of the station is stored in the LYING_SNOW_HT column (in decametres). The LYING_SNOW_HT_Q column is used to indicate the meaning of a null value - 0 means that there was no snow observed, 120 means that the reading is missing and 130 means that no observation was possible due to the hills being obscured. All non-null values have a LYING_SNOW_HT_Q value of 0.

Observers could also enter the height of lowest lying snow as being at station level. The values stored in these cases are the height of the station rounded down to the nearest 10 metres.

DESCRIPTION	UNITS	DETAILS	MIDAS TABLE/COLUMN
Height of lying snow	dm	Daily manual assessment of lowest height of lying snow	weather_drnl_ob/ lying_snow_ht

4.2 Source capability

A key table in MIDAS is **src_capability** which records the classes of observational data stored in the database. For each station a capability is defined by met domain, identifier type and identifier and has a start and end date. For example, amongst the many capabilities of Heathrow are the following:

SYNOP under WMO 03772 from 1949 to 3999 (3999 = currently open)
NCM under DCNN 5113 from 1982 to 3999
SREW under WMO 03772 from 1994 to 3999
SSER under RAIN 247537 from 1988 to 2003

It is possible at many stations having a complex observing history that there may be alternative sources for a given meteorological parameter. On any one date hourly rainfall may have been logged by a SSER system as well as being reported in the SREW message; while at another station daily rainfall may be reported from a TBR as well as from a 5 inch gauge. Each capability will have an entry in the source capability table and will refer to set of data records in MIDAS stored under a particular met domain and identifier. To simplify data extraction for those users unfamiliar with the observing history at the station the concept of **prime capability** has been introduced. Where the attribute in the table has been set equal to prime the corresponding data records are preferred and are guaranteed free of duplicates. Gaps in the data records of any prime capability cannot be ruled out, and non-prime sources can be searched.

The SRC-CAPABILITY table defines, for each source ID, what ID-types and Met domains records they may have between what dates.

4.3 Attributes for each observation record

Each observation record has attributes which identify the station, observation period, observed value, quality flags and instrumentation information. The following describes some of the attributes in use. Further details are given in the MIDAS handbook.

4.3.1 Station identifier

The station source for each observation record is defined by the unique source identifier (SRC_ID) and ID_TYPE and ID, where ID_TYPE is WMO, DCNN, ICAO, RAIN, WIND, CLBD. (*plus LPMS which was used up until 1993 and only refers to one station, Glasgow LPMS.*) In MIDAS the term '**source**' is used as the means of identifying where an observation has originated. Each MIDAS source is uniquely defined by its source identifier (src_id), an attribute that appears in each table containing meteorological data. Stations are uniquely determined by a source identifier which is an integer running from 1 upwards. All observations in the database are stored with their source identifier. Each source identifier has a unique position, defined by the grid reference of the station, and a source name.

4.3.2 Met Domain

The Met Domain specifies the source of the observations in the record. Typically it will identify the message type by which the observations were received (e.g. SYNOP, NCM). Observations under one Met Domain may be spread across a number of tables; for instance, the daily observations from a climate station entered on Form 3208 are stored in up to 6 MIDAS tables under Met Domain 'DLY3208'. Met Domain is a key attribute in the Source Capability table. Met Domains in use for UK surface records are listed below:

AWSDLY	Elements from a Mini MMS data logger reporting 12/24 hourly
AWSHRLY	Elements from a Mini MMS data logger reporting hourly
DLY3208	Elements from Metform 3208, or, more generally, a daily climate return
HCM	Elements from the Hourly Climatological Message
METAR	Elements from FM 15 METAR message
NCM	Elements from National Climatological Message, including climate reports pre 1982
SREW	Hourly rainfall from SREW message
SYNOP	Elements from FM 12-VII SYNOP message (and state of ground from NCM)
WADRAIN	Daily rainfall amounts from rainfall network
WAMRAIN	Monthly rainfall amount from rainfall network

Early Met Domain names are shown in Appendix B.

4.3.4 Version Number

Where quality control is performed and changes are made to the observed value to correct for errors it is important that the original value is not lost. When a change is made to any value in a table record, the original record is stored with Version Number 0 and a new record is created for the corrected version having version number 1. Any further changes are made to version number 1, so that at any time no more than 2 versions exist, the original and the current best version. On initial storage all new records are given Version Number 1. A table will not have Version Number as an attribute if no quality control is ever performed on the observations.

4.3.5 Observation time or period

MIDAS does not use the Database Management System's representation of time.

Where an observation is valid at a specific instant, that date/time is defined by the OB_TIME which has the format 'dd/mm/yyyy hh/mm/ss'. E.g., a dry bulb temperature read at 0900 on 18/03/2013 would have an OB_TIME of '18/03/2013 09:00:00'.

Where an observation is valid over a period of time that period is defined by the date/time at the end of the period, the OB_END_TIME plus an hour count (OB_HOUR_COUNT). E.g., a maximum air temperature read at 0900 on 18/03/2013 would have an OB_END_TIME of '18/03/2013 09:00:00' and an OB_HOUR_COUNT of 12. In other words the maximum temperature is that over the previous 12 hours.

In the case of daily rainfall data, the period is defined by the OB_DATE, OB_END_TIME and OB_DAY_COUNT. E.g., the previous 24 hours of rainfall read at 0900 on 18/03/2013 would have OB_DATE = '18/03/2013', OB_END_TIME = '0900', and OB_DAY_COUNT = 1.

4.3.6 Observed Value

In many cases the observed value is stored as received though, as described in section 4.1, some processing of raw data or conversion from outdated measuring units may have been performed.

4.3.7 Stamp Time

METO_STMP_TIME is the time that a record passed through the first gateway at Exeter, i.e. MetDB for real time observations. The attribute MIDAS_STMP_ETIME is the additional time taken to reach MIDAS, either the time taken to transfer the data from MetDB, or the time taken to complete the loading of a file of data. Where a record is amended,

MIDAS_STMP_ETIME is the interval between initial entry and the final change made. Stamp times are only stored in the default segment tables (those ending in ‘_ob’).

4.3.8 Record State Indicator

The Record State Indicator provides information, over and above that contained in the Version Number, on the changes and processes that have been applied to the data record since its first creation. The meaning of the different values taken by the Record State Indicator are listed at section 5.3.

4.3.9 Quality Indicator

Where quality control is performed a quality control code is stored in the record under an attribute having a suffix ‘_q’ added to the attribute name of the observed value. Section 5 provides more details on the quality control codes in use. It should be noted that prior to the introduction of the MIDAS database on 26 February 1997 very little quality control information was stored in electronic format. Quality control has been performed since the very earliest days of keeping climate records and any changes made were recorded in red on the paper form, but this information was never transferred to the Climate Data Bank (CDB), the precursor to MIDAS. Corrected values were entered into the CDB but the original electronic records were not kept in all cases, with the exception of daily rainfall.

4.3.10 J-Descriptor

Many observed values in the MIDAS tables have an associated J-Descriptor identified by the suffix J added to the attribute name. J-Descriptors are values of a code table which provide more information on the nature of the observation and perhaps the processing methods that have been applied. In this aspect MIDAS is self-documenting in that the tables CODE and CODE-DETAIL provide all the details.

4.4 Synoptic Observations

4.4.1 The Synoptic Network

The international SYNOP message, based on formats which have changed over the years, has been used for the real time transmission of synoptic weather observations since 1949. The stations may be manned, part-manned or automatic. The UK practice for many years has regarded the actual observation time as HH-10.

Storage in the ‘weather_hrly_ob’ table:

ID_TYPE	WMO
ID	WMO number
MET_DOMAIN	SYNOP
OB_TIME	Given as HH but varied between HH-0 and HH-10 depending on local practice at the time. HH-15 for SIESAWS (when they were still in use).
Met Elements	Mean sea level pressure, station level pressure, air temperature, dew point, 10-min wind speed, 10-min wind direction, visibility, total cloud, other cloud type/amount/height information, present weather, past weather 1 & 2, state of ground, hourly (WMO) sunshine (Daily sunshine is reported at 0600 and stored in weather_drnl_ob table.).

4.4.2 The Aviation Network

Synoptic observations for aviation purposes use the METAR code. Most stations report at least hourly.

Storage in the ‘weather_hrly_ob’ table:

ID_TYPE	ICAO
ID	ICAO identifier

MET_DOMAIN	METAR
OB_TIME	Given as HH. Local practice normally HH-10, and HH+20 at civil airports, but only former stored in MIDAS
Met Elements	Altimeter pressure, air temperature, dew point, 10-min wind speed, 10-min wind direction, maximum 10-min gust speed, visibility, vertical visibility, cloud amount/height information, present weather

Storage in the 'runway_ob' table:

ID_TYPE	ICAO
ID	ICAO identifier
MET_DOMAIN	METAR
OB_TIME	Given as HH, but can vary with local practice
Met Elements	Runway visual range, runway designator

4.4.3 Mini MMS Network (AWS)

With the introduction of MMS many of the CDL (climate data logger) stations have been replaced by MMS which produces minute data with hourly observations being stored in MIDAS. Observations are stored under the DCNN number. These sites were also allocated 5 digit CLBW numbers beginning with 99 for transmission on the GTS. These stations are part of the supplementary Synoptic network. This is because they do not record the full set of elements like those that are in the SYNOP network. The most basic station records; air temperature, humidity and rainfall with some recording wind direction, wind speed and radiation. These stations have an id_type of DCNN. There are also currently 6 commercial stations which produce minute data through MMS and are "ring fenced" by the use of the distinct ID_TYPE CLBD. These sites have a non-standard exposure

Storage in the 'weather_hrly_ob' table:

ID_TYPE	DCNN CLBD for commercial stations with non-standard exposure
ID	DCNN number
MET_DOMAIN	AWSHRLY
OB_TIME	HH-10.
Met Elements	One or more of: Mean sea level pressure, air temperature, relative humidity, 10-min wind speed, 10-min wind direction.

Storage in 'weather_drnl_ob' table

ID_TYPE	CLBD commercial stations with non-standard exposure
ID	DCNN number
MET_DOMAIN	AWSDLY
OB_END_TIME	HH-10.
OB_HOUR_COUNT	24
Met Elements	Derived 24hr sunshine duration

Storage in the 'temp_drnl_ob' table:

ID_TYPE	DCNN CLBD for commercial stations with non-standard exposure
ID	DCNN number
MET_DOMAIN	AWSDLY
OB_END_TIME	HH-10.
OB_HOUR_COUNT	12
Met Elements	One or more of: Maximum air temperature, minimum air temperature, minimum grass temperature and minimum concrete temperature

Storage in the 'rain_hrly_ob' table:

ID_TYPE	DCNN CLBD for commercial stations with non-standard exposure
ID	DCNN number
MET_DOMAIN	AWSHRLY
OB_END_TIME	HH-10.

OB_HOUR_COUNT 1 (hourly) and 12 (0900 and 2100)
 Met Elements Precipitation amount

Storage in the 'soil_temp_ob' table:

ID_TYPE DCNN
 ID DCNN number
 MET_DOMAIN AWSHRLY and AWSDLY
 OB_TIME HH-10.
 Met Elements One or more of: 10cm, 30cm and 100cm soil temperatures (10cm temperature is hourly. 30 and 100cm temperatures are daily)

Storage in the 'wind_mean_ob' table:

ID_TYPE CLBN
 ID WIND number
 MET_DOMAIN AWSHRLY
 OB_END_TIME HH-10.
 OB_HOUR_COUNT 1
 Met Elements One or more of: mean wind direction, mean wind speed, maximum gust direction, maximum gust speed, maximum gust time

4.5 Climate Observations

4.5.1 Synoptic stations producing National Climate Messages

National Climate Messages (NCM), produced from all Met Office stations, are transmitted in the same way as SYNOPs. A full message is sent at 0900 each day and most stations also send a further message at 2100 containing limited data. Note that, as was the case for SYNOP reports, the periods of the observations start and end 10 minutes before the main hour. Some local variation may have existed in the past, e.g. 0900 being the time the rainfall was read.

(a) Storage in the 'temp_drnl_ob' table:

ID_TYPE DCNN
 ID DCNN number
 MET_DOMAIN NCM from 1982
 DLY3208 pre 1982
 OB_END_TIME Given as 0900 or 2100, but in fact normally 0850 and 2050.
 OB_HOUR_COUNT 12 or 24
 Met Elements Maximum temperature, minimum temperature, grass minimum temperature (0900-0900 only), concrete minimum temperature (0900-0900 only).

(b) Storage in the 'weather_drnl_ob' table:

ID_TYPE DCNN
 ID DCNN number
 MET_DOMAIN NCM from 1982
 DLY3208 pre 1982
 OB_END_TIME 0900, 2100 or 2359 (2359 for sunshine and "days of" only)
 OB_HOUR_COUNT 12 or 24
 Met Elements Sunshine duration (0000-2359), depth of snow (at 0900), depth of fresh snow (0900-0900), day of snow/hail/thunder/fog/gale (between 0000-2359), state of concrete slab (at 0900).

(c) Storage in the 'weather_hrly_ob' table:

ID_TYPE WMO
 ID WMO number
 MET_DOMAIN NCM (if no SYNOP report received)
 SYNOP (NCM overwrites SYNOP value but met domain remains SYNOP)

OB_TIME	0000, 0300, 0600, 2100
Met Elements	State of ground

(d) Storage in the 'soil_temp_ob' table:

ID_TYPE	DCNN
ID	DCNN number
MET_DOMAIN	NCM
OB_TIME	Given as 0900, but in fact normally 0850.
Met Elements	Soil temperature at 30 and 100 cm.

(e) Storage in the 'rain_hrly_ob' table:

See 4.6.1 and 4.6.2.

4.5.2 Stations producing Hourly Climate Messages

Hourly Climate Messages (HCM), produced from automated MMS stations are transmitted in real time in the same way as SYNOPs, but the HCM covers the period of the full synoptic hour, HH-60 to HH-0. The message contains wind, soil and radiation observations covering the hour period.

(a) Storage in the 'soil_temp_ob' table:

ID_TYPE	DCNN
ID	DCNN number
MET_DOMAIN	NCM (at 0900 only; table also contains 30 and 100 cm soil temperatures that are reported in NCM message) ESAWSOIL (at all hours except 0900 – Not in use anymore since the introduction of MMS)
OB_TIME	Given as HH, but in fact normally HH-10.
Met Elements	Soil temperature at 10 cm.

(b) Storage in 'wind_mean_ob' and 'radt_ob' tables

See sections 4.7 and 4.9.

4.5.3 Data from Mini MMS Data Loggers

Climate observations are generated by all Mini MMS sites (previously known as CDL). All observations are transmitted in real time and produce minute data. The elements recorded varies from station to station. All MMS stations submit hourly observations (Met Domain AWSHRLY is used) and 12/24-hourly observations (Met Domain AWSDLY is used).

(a) Storage in the 'temp_drnl_ob' table:

ID_TYPE	DCNN
	CLBD for commercial stations with non-standard exposure
ID	DCNN number
MET_DOMAIN	AWSDLY
OB_END_TIME	0900 or 2100, but in fact normally at 0850 and 2050.
OB_HOUR_COUNT	12 or 24
Met Elements	Maximum temperature, minimum temperature, Grass minimum temperature (0900-0900 only), concrete minimum temperature (0900-0900 only)

(b) Storage in the 'soil_temp_ob' table:

ID_TYPE	DCNN
	CLBD for commercial stations with non-standard exposure
ID	DCNN number
MET_DOMAIN	AWSHRLY or AWSDLY
OB_TIME	Hourly, or 0900 only
Met Elements	Soil temperature at 10, 30, and 100 cm.

(c) Storage in 'rain_drnl', 'wind_mean_ob' and 'radt_ob' tables

See sections 4.6, 4.7 and 4.9.

4.5.4 Daily climate returns from Ordinary Climatological Stations

Climate stations normally make one observation a day, though over the years practices have changed and twice or three times a day observing was more common than it is today. With the introduction of OWL and more recently WOW, most stations submit their readings on a daily basis. The paper form, covering a month's observations, is still used by some stations. The form is known as Met Form 3208b and contains up to 31 daily observations. The observation time at most stations is 0900, though a few observe at other hours between 0700 and 1000 (Please note it is only possible to store them as 0900 in MIDAS). Not all stations have the equipment to produce all the following meteorological elements.

(a) Storage in the 'temp_drnl_ob' table:

ID_TYPE	DCNN (and LPMS until 1993, for one site - Glasgow LPMS)
ID	DCNN number
MET_DOMAIN	DLY3208. (Although the 3208 form was only introduced in 1959 this Met Domain is used irrespective of the date.)
OB_END_TIME	0900 (in a few instances other hours between 0700 and 1000).
OB_HOUR_COUNT	24
Met Elements	Maximum temperature, minimum temperature, grass minimum temperature, concrete minimum temperature.

(b) Storage in the 'weather_drnl_ob' table:

ID_TYPE	DCNN (and LPMS until 1993, for one site - Glasgow LPMS)
ID	DCNN number
MET_DOMAIN	DLY3208. Although the 3208 form was only introduced in 1959 this Met Domain is used irrespective of the date.
OB_END_TIME	0900 (in a few instances other hours between 0700 and 1000). 2359 for sunshine.
OB_HOUR_COUNT	24
Met Elements	Sunshine duration (0000-2359), depth of snow (0900), depth of fresh snow (0900), day of snow/hail/thunder/gale (0000-2359).

(c) Storage in the 'weather_hrly_ob' table:

ID_TYPE	DCNN
ID	DCNN number
MET_DOMAIN	DLY3208. Although the 3208 form was only introduced in 1959 this Met Domain is used irrespective of the date.
OB_TIME	0900 (in a few instances other hours between 0700 and 1000).
Met Elements	Air temperature, wet-bulb temperature, wind speed, wind direction, visibility, cloud amount, present weather, state of ground

(d) Storage in the 'soil_temp_ob' table:

ID_TYPE	DCNN
ID	DCNN number
MET_DOMAIN	DLY3208. Although the 3208 form was only introduced in 1959 this Met Domain is used irrespective of the date.
OB_TIME	0900 (in a few instances other hours between 0700 and 1000).
Met Elements	Soil temperature at 10, 20, 30, 50 and 100 cm.

(e) Storage in the 'rain_drnl_ob' table

See section 4.6.

(f) Storage in 'wind_mean_ob' table

See section 4.7.

4.6 Rainfall observations

4.6.1 Hourly rainfall measured by TBR

With the introduction of MMS almost all SYNOPTIC and supplementary SYNOPTIC sites use a TBR to record rainfall. There are a few sites from the supplementary network that just measure single elements such as wind. With the MMS system, the data logger can record minute by minute data.

Storage in the 'rain_hrly_ob' table:

ID_TYPE	RAIN
ID	Rainfall number for TBR gauge
MET_DOMAIN	SREW AWSHRLY
OB_HOUR_COUNT	1
OB END TIME	HH-70 to HH-10 for all MMS stations
PRCP_AMT	To nearest 0.2mm

4.6.2 12-hourly rainfall measure by TBR

This reading is measured using the same TBR as used for the hourly readings. The reading is sent in the NCM message or for non SYNOP sites a shortened NCM message under AWSDLY.

Storage in the 'rain_hrly_ob' table:

ID_TYPE	RAIN
ID	Rainfall number for TBR gauge
MET_DOMAIN	NCM AWSDLY
OB_HOUR_COUNT	1
OB END TIME	0900 or 2100. Observation usually taken at HH-10 and is for the period HH-70 to HH-10
PRCP_AMT	To nearest 0.2mm

4.6.3 Daily/monthly rainfall measured by a 5" rain gauge or TBR

(a) The rainfall network

The rainfall network in the UK consists of well over 1000 stations that use a 5" storage rain gauge where the sole observation is rainfall. These are a mixture of both daily and monthly reading stations although predominantly the former. The daily sites have a single 5" gauge which is read once a day, though at some sites observations are made less frequently. There are also just over 1000 TBR stations and daily accumulations from these stations are sent to the Met Office from partnering organisations. Many of the gauges are owned and operated by the Environment Agency, SEPA, Water & Energy companies and the Met Office. All stations should report daily values at 0900, however in practice a number of manual 5" stations can report early or late. Monthly values are reported on the first day of the following month at 0900. Again this can vary from station to station with some reporting their values earlier or later than this.

Storage in the 'rain_drnl_ob' table:

ID_TYPE	RAIN
ID	Rainfall number of 5" gauge or TBR
MET_DOMAIN	WADRAIN for daily stations (though not all stations report daily) WAMRAIN for monthly stations
OB_DAY_COUNT	1, 2, ... 31 as appropriate

OB_END_TIME 0900
 PRCP_AMT To nearest 0.1mm or trace

(b) The climate network

Around 185 stations in the UK provide daily climate observations which include rainfall. These are returned through a combination of WOW and 3208 paper form. Some stations do not report every day (e.g. not at weekends). As with the rainfall network, some stations do not take their observations at 0900.

Storage in the 'rain_drnl_ob' table:

ID_TYPE RAIN
 ID Rainfall number of 5" gauge, or TBR
 MET_DOMAIN DLY3208
 OB_DAY_COUNT 1, 2, .. as appropriate
 OB_END_TIME 0900 (in a few instances other hours between 0700 and 1000).
 PRCP_AMT To nearest 0.1mm or trace

A description of early rainfall recording methods and their storage in MIDAS is given in **Appendix D**.

4.7 Wind Observations

4.7.1 Wind from the Hourly Climate Message

With the introduction of MMS, Hourly Climate Messages (HCM) are produced based on the minute data received. All hourly values are drawn from the sampling period HH-70 to HH-10. Mean Wind Speed and Wind Direction is an average of the 60 minute values rounded to the nearest knot for wind speed and the nearest 10 degrees for wind direction. The maximum gust speed is the highest gust during the hour. The direction and time of the maximum gust are also reported.

Storage in the 'wind_mean_ob' table:

ID_TYPE WIND
 ID Wind number
 MET_DOMAIN HCM
 OB_END_TIME Given as HH but is in fact HH-10
 OB_HOUR_COUNT 1 (for period HH70-HH10)
 Met Elements Mean wind speed, mean wind direction, maximum gust speed in hour, direction of maximum gust, time of maximum gust.

4.7.2 Hourly gusts from the SYNOP report

Where a gust in excess of 25 kt is observed in the period HH-70 to HH-10 it is reported in a special group of the SYNOP message. The time of the gust is not reported.

Storage in the 'wind_mean_ob' table:

ID_TYPE WMO
 ID WMO number
 MET_DOMAIN SYNOP
 OB_END_TIME Given as HH but is in fact HH-10
 OB_HOUR_COUNT 1
 Met Element Speed and direction of max. gust
The value is overwritten by hourly wind data from (a) the HCM, or (b) in the past, the 6910 analysis. In general all values are eventually overwritten unless (a) or (b) are missing for some reason (telecoms fault, failure to perform 6910 analysis).

4.7.3 10-minute winds

Observations of mean wind and gusts over a 10-min period preceding the observation time (typically HH-40 to HH-50) are reported in the SYNOP and METAR messages and stored in the weather_hrly_ob table.

A description of early wind recording methods and their storage in MIDAS is given in **Appendix C**.

4.8 Sunshine

4.8.1 Daily sunshine measured by Campbell-Stokes Instrument

Daily sunshine readings were first taken in 1880 at Glasgow LPMS and have been made at a number of manual sites ever since with a number of automatic sites taking check readings in more recent times. A Campbell-Stokes instrument was used which concentrates sunlight on a sunshine card when the sun shines. This is then manually checked by the observer at the station and a total value of sunshine hours given.

In the past a number of synoptic stations performed an analysis of hourly sunshine from the sunshine card on a Campbell-Stokes instrument and returned the values monthly on form 3445.

Storage in the 'weather_drnl_ob' table:

ID_TYPE	DCNN
ID	DCNN number
MET_DOMAIN	DLY3208
OB_END_TIME	2359
OB_HOUR_COUNT	24
Met Element	Sunshine duration

4.9 Radiation

4.9.1 Radiation from the Hourly Climate Message

Hourly observations of the near surface radiation fluxes are reported in the HCM message.

Storage in the 'radt_ob' table

ID_TYPE	DCNN
ID	DCNN number
MET_DOMAIN	HCM
OB_END_TIME	Given as HH, but in fact normally HH-10.
OB_HOUR_COUNT	1
Met Elements	Radiation fluxes

4.9.2 Radiation from the main SYNOP stations

Daily observations of the near surface radiation fluxes are reported from SYNOP stations on a daily basis at 2359. Up until 31/12/2010 some hourly readings for SYNOP stations appear in MIDAS but the number of these vary from month to month.

Storage in the 'radt_ob' table

ID_TYPE	WMO
ID	WMO number
MET_DOMAIN	SYNOP

OB_END_TIME	HH or 2359
OB_HOUR_COUNT	24 (also hourly until 31/12/2010)
Met Elements	Radiation fluxes

4.9.3 Radiation from the other AWS and commercial stations

Hourly observations of the near surface radiation fluxes are reported from AWS and commercial stations. Some stations also take 24 hr readings.

Storage in the 'radt_ob' table

ID_TYPE	DCNN or CLBD (commercial stations)
ID	DCNN number
MET_DOMAIN	AWSHRLY
OB_END_TIME	HH or 2359
OB_HOUR_COUNT	1 or 24
Met Elements	Radiation fluxes

A description of early radiation recording methods and their storage in MIDAS is given in **Appendix C**.

5. Quality control

5.1 General Principles

Each meteorological element in MIDAS, for which quality control is possible, has 5 associated flags. The definition of each of the flags is given in section 5.2 below. The flags are stored in the same table as the meteorological element to which they refer under an attribute having an appropriate name ending in `_Q`. The flags describe the character and quality of the observation and may be set at any time by automatic or manual procedures.

Each record in MIDAS has an attribute Version Number which may take the value 0 or 1 only. A new record, on first being stored in MIDAS, always has a Version Number of 1. Should a change be made to the original value of any meteorological element, either as a correction of an error or as an estimate of a missing value, the original record is stored with Version Number 0 and the new record, containing the corrections or estimates, is stored with Version Number 1 (n.b. if all the values in the original record were missing, version 1 contains the estimate(s) and there will be no version 0). A record with Version Number 1 represents, therefore, the best available values of the meteorological elements at the time in the sense that they have been the subject of at least some minimum level of quality control. Information on the level of the quality control performed and the results of the checks made is contained in the quality control flags for each element. Should further changes be made, the record with Version Number 1 is updated while Version Number 0 remains unchanged. Information on what changes were made to the record during the intermediate stages of quality control is not retained.

In almost all cases the existence of a record with Version Number 0 implies that a record with the same station identifier, date/time and Met Domain should exist with Version Number 1. There are two exceptions. The hourly rainfall table where 24-hourly estimates of precipitation are stored in the hourly rainfall table where the sum of the hourly or 12-hourly accumulations is considered to be in error. In such cases the erroneous hourly or 12-hourly values have Version Number 0, but there will be no version 1. A similar practice applies to estimates of 24-hour maximum and minimum temperature where 12-hourly values are considered to be in error.

Corrections may be received from the observing station if manned. Where they are received as a COR message for a report in SYNOP, NCM, HCM or SREW format, the corrections are loaded into MIDAS and overwrite the original values. In other words no original values are retained as a record with Version Number 0.

5.2 Definition of MIDAS Quality Control Flags

Each meteorological element has 5 associated quality flags: marker, estimate, status, query and level, which may be abbreviated as **mesql**.

5.2.1 Marker Flag

The marker flag provides information about trace values and multi-day observations.

Value	Meaning
0	Value is neither a trace or an accumulation
1	Trace precipitation
2	Accumulated value
-2	Value is a trace and an accumulation

Trace applies to rainfall or snow. Accumulation currently only applies to multi-day accumulations of precipitation. In the past maximum and minimum temperatures spanning a period longer than one day (e.g. from stations where the observer is absent at weekends) were recorded, but this practice ended in 2005. 24 hour readings are given for each day with estimates being made where there are days missing.

5.2.2 Estimate Flag

The estimate flag provides information on how the estimate or correction was derived.

Value	Meaning
0	Value is not an estimate or correction, or information on the estimate or correction is not available
1	Estimate/correction has been derived automatically (no manual action)
2	Estimate/correction has been set manually
3	Estimate/correction has been obtained retrospectively from the station
4	For precipitation only: estimate/correction has been derived from snow-rain equivalence, or the trace estimate/correction has been set to ensure consistency with past weather.
5	Correction has been obtained by changing units of measurement
6	Correction has been obtained by applying a systematic adjustment
7	SREW 999 snow or mechanical problems

The estimate flag has no meaning for the original value for which it will always be 0.

5.2.3 Status Flag

The status flag indicates whether the value is an estimate or correction, or, where it is the original value whether it is suspect.

Value	Meaning
0	As observed and not suspect
1	As observed and suspect
2	An estimate – the expected observation is not available
3	An estimate – the original is missing and known to be irretrievable

4	An unreliable estimate – only used for radiation values
5	A correction – the original is considered to be in error
6	Value has reverted to original
7	Original verified by observer

It is perfectly in order for an element to fail a quality control check (as indicated by the query flag below) but not be suspect, for example in an unusual meteorological situation. The reverse may also occur: an observation may pass all automatic checks yet still be considered in error on detailed scrutiny by a member of staff. A correction may simply be a missing value where no sensible estimate can be obtained.

5.2.4 Query Flag

The query flag indicates which quality control checks, if any, the value in question has failed.

Value	Meaning
0	Value has not (yet) failed a quality control check, or no information available
1	Failed MetDB check
2	Failed MIDAS validation (range checks applied at the point of ingestion)
3	Failed QC marine position or movement check
4	Failed QC range check
5	Failed QC internal consistency check
6	Failed QC sequence check
7	Failed QC areal check

Where an element fails more than one check the highest numbered value is stored, with the exception that a value of 1 is stored in preference to a value of 2.

5.2.5 Level Flag

The level flag indicates what level of quality control has been performed so far on the value in question. All data loaded from the CDB had a level flag equal to 9.

Value	Meaning
0	No QC applied
1	QCL quality control checks have run
2	QCL quality control checks have been performed
3	-
4	Range and/or internal consistency checks performed
5	-
6	Areal checks performed
7	-
8	-
9	All QC checks completed

The level flags of original values stored in a record with Version Number 0 remain unchanged from the point at which that record was created.

5.3 Record State Indicator

A record state indicator is an attribute of each table that is used to describe the current stage in the life of a particular record, from creation to deletion.

Record State Indicator settings and their meanings.

1001	Normal ingestion of observation at creation
1002	Normal ingestion of a multi-level observation such as upper air at creation*
1003	Addition of observation level*
1004	Receive a COR before normal observation received
1005	Receive a COR before normal multi-level observation received
1006	Receive a COR to observation level
1007	Addition of a missing value
1008	Receive a COR after the observation received but before QC started
1009	Receive a COR to an observation level after normal receipt but before QC started*
1010	Start of QC ob extracted for QC checks
1011	QC level raised on Version 1
1012	Create Version 0. First QC amend to an attribute other than just change of qc level
1013	Version 0 exists with no version 1
1014	Version 1 exists as apportioned/corrected data with no version 0

Working with Version 1 as corrected data

1022	Version 1 Creation. Version 0 is frozen as original data state indicator 1012
1023	Version 1 of multi-level ob*
1024	QC amend to Version 1 observation multi-level*
1025	Change to qc level in Version 1
1026	Receive subsequent qc amendments
1027	Decision to Archive*
1028	Archive observation*
1029	COR of Key item- pre QC - mark for deletion*

* - No rows currently in MIDAS with these indicators

5.4 Quality control processes performed on MIDAS data

5.4.1 Quality control at the point of observation

Basic quality control is performed at each observing site which ensures that some errors are trapped before being transmitted. In the days before automation, the trained observers were required to check all their entries in the weather register. Observing system software (MMS/WOW) applies a range of checks to all reported parameters which reduce the risk of irregular values leaving the site. The human observer, if present at the time of observation, may override some of the queries raised.

5.4.2 MetDB quality checks

All real time observations that are destined for MIDAS are stored first in the MetDB. These include SYNOP, NCM, HCM, SREW and METAR reports. Some range and self-consistency checks are performed on the values at the point of receipt in the MetDB and the associated flags are passed to MIDAS on data ingestion by setting the query flag equal to 1.

5.4.3 Ingestion checks

All data on ingestion to MIDAS undergo basic range checks. These do no more than ensure that the meteorological value does not lie outside long-term climatological extremes (taking no account of time of year or location). Those failing have query flag set equal to 2.

5.4.4 QCL checks

All UK surface data, with the exception of rainfall data, undergo a set of “QCL” checks soon after their ingestion into MIDAS. A level flag set equal to 1 indicates that QCL checks have been performed. These checks ensure:

- The widest possible self-consistency between the elements in each message
- Consistency with climatological extremes
- Consistency with previous observations from the same source; i.e. checks are applied to the rate of change of the parameter

5.4.5 Checks against neighbours

Spatial checks are applied to certain meteorological elements to ensure consistency with neighbours (areal checks). The elements checked are maximum and minimum air temperatures, grass minimum temperatures, 0900 air temperature, rainfall and sunshine.

5.4.6 Manual quality control

With few exceptions, all messages which resulted in the raising of quality control flags mentioned above are scrutinised by trained meteorological staff. Corrections are supplied and estimates may be made where values are missing.

6. Global land observations

MIDAS contains a table for non-UK global land surface observations called, `gbl_wx_ob`. This contains data from synoptic sites around the world that are received via the GTS, processed by the MetDB, and then loaded into MIDAS on a daily basis. The data are loaded at midnight, 24 hours in arrears. E.g. After data are ingested at midnight on 31st January there will be data available up to 2300 on the 30th January.

The `gbl_wx_ob` table is similar to the `weather_hrly_ob` table, as the data loaded to both tables originate from the same types of observations messages: SYNOPs and METARs. Many of the observations are 3-hourly, though hourly data are available from some sites.

Appendix A: Formula for calculation of radiation threshold value for “sunshine”

A threshold value for short wave radiation is calculated each minute and compared with the measured value; if the measurement exceeds the threshold then the minute is counted as sunny.

The threshold is derived from the following equation:

$$\text{Threshold} = (1030 \times (\sin(\text{ModH}))^{1.22}) \times (0.88 - 0.16 \times \sin((\text{JulianDay}-5)/2))$$

ModH is the angle of elevation of the sun corrected for the effect of refraction. It is calculated through the application of the following series of equations:

1: $D = 2\pi \times \text{Julian day}/365$ (or 366 in a leap year), Julian day being the date in days through the year.
(sticking to radians throughout).

Now we need the equation of time:

$$\text{2: } ET = 229.18 \times (0.000075 + 0.001868 \times \cos(D) - 0.032077 \times \sin(D) - 0.014615 \times \cos(2 \times D) - 0.04089 \times \sin(2 \times D))$$

From which we calculate local solar time during the length of the day.

So on a minute by minute basis:

$$\text{3: } LST = Tm + 4 \times LO + ET$$

Where Tm is the UT time (in minutes through the day from 0 to 1440), LO is longitude in degrees E.

From this we calculate a minute by minute value of the hour angle HA:

$$\text{4: } HA = 2\pi \times (LST - 720) / 1440$$

Now we need to calculate the declination (just a single daily figure):

$$\text{5: } DEC = 57.296 \times (0.006918 - 0.399912 \times \cos(D) + 0.070257 \times \sin(D) - 0.006758 \times \cos(2 \times D) + 0.000907 \times \sin(2 \times D) - 0.002697 \times \cos(3 \times D) + 0.00148 \times \sin(3 \times D))$$

NB this gives DEC in degrees.

And from this and other parameters the next calculation is sinH, the sine of the angle of elevation of the sun throughout the day.

$$\text{6: } \sin H = \sin(\pi \times LA / 180) \times \sin(DEC \times \pi / 180) + \cos(\pi \times LA / 180) \times \cos(DEC \times \pi / 180) \times \cos(HA)$$

Where LA is the latitude in degrees. Now to get the angle of elevation uncorrected for refraction:

$$\text{7: } H = \text{asin}(\sin H)$$

H here will need to be expressed in degrees. Now the refraction correction

8: Either a) When Elevation $H < -0.56^\circ$ then Refraction = $+0.56^\circ$

Otherwise b) Refraction = $(c1*(c2+c3*H+c4*H^2))/(c5+c6*H+c7*H^2)$

Where $c1 = 3.5156$, $c2 = 0.1594$, $c3 = 0.0196$, $c4 = 0.00002$, $c5 = 1.0000$, $c6 = 0.5050$, $c7 = 0.0845$

So finally,

9: ModH = H + Refraction

Appendix B: Early Met Domain Names

DLY3259	Elements from Metform 3259 (pre 1982 NCM message)
DRADR35	Elements from Met O 1 Form R35 – radiation/sunshine
ESAWRADT	Hourly radiation from ESAWS
ESAWSOIL	Hourly soil temperatures from ESAWS
ESAWWIND	Mean hourly wind from ESAWS
HSUN3445	Elements from Metform 3445 – analysis of hourly sunshine
HWNDAUTO	Elements from automatic wind loggers
HWND6910	Elements from Metform 6910 – analysis anemograms
MODLERAD	Hourly radiation values from MODLE
SSER	Rainfall amounts from SSER loggers
WAHRAIN	Hourly rainfall values from analysis of TSR autographic records

The Met Domain table in MIDAS lists the possible values this parameter may take, not all of which have been used. Use of the following met domains will be discontinued (many of which have never been used):

AWSRADT, AWSSOIL, AWSWIND, CAWS, DLY3259 – updated to NCM pre 1982,
ESAWRADT, ESAWSOIL, ESAWWIND, RADTOB, RADXOB, RNDYOB, RNHROB,
RNSHRLY, RUNWAY, SOILOB, SSERADJ, SSEADLY, SUNHRLY, TDYOB, TEMPMNSL,
WADLOG, WINDMEAN, WXDYOB, WXHROB

Appendix C: Early recording methods and storage of data in MIDAS

1. Early rainfall recording methods

Pre MMS there was a large number of different methods for recording rainfall. Details are shown below to help when looking through retrospective rainfall data.

1.1 Hourly rainfall measured by a 5" gauge

The hourly accumulation from a 5" gauge is reported in a SREW message which is sent under the station's WMO number. Although the raingauge used for the measurement is often different from the one used for the NCM observation, it is usually always at the same site and given the same rainfall number. The reporting practice does not apply if a TBR is installed at the site, which is the case at most stations today. In the CDB, the SREW was overwritten by hourly rainfall from the 7113 form (TSR, see 2 below).

Storage in the 'rain_hrly_ob' table:

ID_TYPE	RAIN
ID	Rainfall number of 5" gauge
MET_DOMAIN	SREW
OB_HOUR_COUNT	1
OB_END_TIME	Given as HH but varied between HH-0 and HH-10 depending on local practice at the time
PRCP_AMT	To nearest 0.1mm or trace
PRCP_DUR	Missing

1.2 Hourly rainfall measured by a TSR

The analysis of hourly rainfall accumulation and duration (where rate ≥ 0.1 mm/hr) from the TSR (Tipping Syphon Raingauge) autographic record was returned on a 7113 form. Instructions issued to observing stations stated that the daily accumulation, obtained by summing the analysed hourly totals, should be adjusted to equal the reported daily total from the 5" gauge obtained from the sum of the two 12-hour NCM reports. It is thought that this practice was followed at most, if not all, stations over the years. In the CDB the hourly values overwrite the SREW. At most stations the 7113 analysis ceased with the introduction of automatic reporting of hourly values from a TBR (SSER or SAMOS systems).

Storage in the 'rain_hrly_ob' table

ID_TYPE	RAIN
ID	Rainfall number of 5" gauge (Note: not TSR)
MET_DOMAIN	WAHRAIN
OB_HOUR_COUNT	1
OB_END_TIME	HH. Is a true HH-0 to HH-0 accumulation
PRCP_AMT	To nearest 0.1mm or trace
PRCP_DUR	To nearest 0.1 hour (6 min)

1.3 Hourly rainfall measured by a TBR

(a) SSER

SSER (Solid State Event Recorder) systems were introduced at more than 50 stations during 1987. They consist of a data logging device attached to a TBR. Solid state cassettes on which tip times are stored were returned to the Met Office at the end of each month for downloading, processing and storage in the Climate database. At some time in the past the calculated hourly SSER accumulations have been adjusted so that their 24-hour sum equals the value from the 5" gauge reported in the NCMs, a similar practice to that for the analysis of TSR autographic records. This adjustment is not performed today since the NCM value now originates from the same TBR, not from a 5" gauge.

Storage in the 'rain_subhrly_ob' table:

ID_TYPE	RAIN
ID	Rainfall number of TBR gauge
MET_DOMAIN	SSER
OB_TIME	Tip time to nearest minute
PRCP_TIP_AMOUNT	0.2mm

Storage in the 'rain_hrly_ob' table:

ID_TYPE	RAIN
ID	Rainfall number of TBR, even if adjusted
MET_DOMAIN	SSER
OB_HOUR_COUNT	1
OB_END_TIME	HH. Is a true HH-0 to HH-0 accumulation calculated from tip times
PRCP_AMT	To nearest 0.2mm
PRCP_DUR	Missing

SSER values, which are received after the end of each month, overwrite any SREW values that derive from the same rain gauge. Before 1997, there are no hourly SSER values for those few stations that have no WMO number. There is also storage in RAIN_DRNL table of derived 24-hour SSER totals pre 1997.

(b) MTER

Between 1978 and 1986 MTER (Magnetic Tape Event Recorder), which was an earlier version of the SSER logging system, was in use at a number of stations. Data were produced and processed in the same way as those from SSER and they are stored in the database under the SSER Met Domain.

(c) ESAWS and SAMOS

ESAWS, which was fully automatic, and SAMOS, which was operated in manned, semi-manned or automatic mode, produced SREW reports in real time. In both systems output from a TBR was converted to hourly accumulations. SAMOS sometimes operated alongside a SSER logging device.

Storage in the 'rain_hrly_ob' table:

ID_TYPE	RAIN
ID	Rainfall number of TBR gauge. Where both SAMOS and SSER systems are connected to the same TBR the observations are stored under different rainfall numbers
MET_DOMAIN	SREW
OB_HOUR_COUNT	1
OB_END_TIME	Given as HH but is in fact HH-70 to HH-10 accumulation
PRCP_AMT	To nearest 0.2mm. Trace may be reported if manned SAMOS
PRCP_DUR	Missing

(d) CDL

Like ESAWS and SAMOS systems, the CDL logged rainfall from a TBR. Some CDLs transmitted hourly accumulations of rainfall in real time and others logged the data locally which was then either polled remotely or sent monthly on a disk. The Met Domain was not used to identify the transmission method and all hourly observations were stored under AWSHRLY.

Storage in the 'rain_hrly_ob' table:

ID_TYPE	RAIN for stations part of the Core synoptic network CLBR for commercial stations with non-standard exposure
ID	Rainfall number of TBR gauge
MET_DOMAIN	AWSHRLY
OB_HOUR_COUNT	1
OB_END_TIME	HH. Is a true HH-0 to HH-0 accumulation calculated from tip times

PRCP_AMT To nearest 0.2mm
 PRCP_DUR Missing

1.4 12-hourly rainfall measured by a 5" gauge

Measurement from a 5" gauge was the standard climate observation of rainfall from synoptic stations since the earliest years. Since 1982 the value was sent in the NCM message; before that date manuscript climate returns on the 3259 form were sent from each station. Other climate forms were used in the first part of the century.

Storage in the 'rain_hrly_ob' table:

ID_TYPE RAIN
 ID Rainfall number of 5" gauge
 MET_DOMAIN NCM
 OB_HOUR_COUNT 12
 OB_END_TIME 0900 or 2100. Observation taken as close to the hour as possible, usually between HH-5 and HH
 PRCP_AMT To nearest 0.1mm or trace
 PRCP_DUR Missing

1.5 12-hourly rainfall measured by a TBR

(a) ESAWS and SAMOS

ESAWS and SAMOS systems produced 12-hour accumulations of rainfall from the TBR. In all cases the 12-hour accumulation equalled the sum of the previous 12 hourly accumulations stored in MIDAS under Met Domain SREW. (Although instrumental software errors at the time resulted in isolated cases of erroneous 12-hour NCM accumulations).

Storage in the 'rain_hrly_ob' table:

ID_TYPE RAIN
 ID Rainfall number of TBR gauge
 MET_DOMAIN NCM
 OB_HOUR_COUNT 12
 OB_END_TIME Given as 0900 or 2100 but is in fact 0850 or 2050
 PRCP_AMT To nearest 0.2mm. Trace may be reported if manned SAMOS
 PRCP_DUR Missing

(b) CDL

As for hourly rainfall, the distinction between Core and commercial CDLs is achieved through the use of different ID_TYPES.

Storage in the 'rain_hrly_ob' table:

ID_TYPE RAIN for stations part of the Core synoptic network
 CLBR for commercial stations with non-standard exposure
 ID Rainfall number of TBR gauge
 MET_DOMAIN AWSDLY
 OB_HOUR_COUNT 12
 OB_END_TIME 0900 or 2100 exactly, unlike ESAWS or SAMOS systems
 PRCP_AMT To nearest 0.2mm
 PRCP_DUR Missing

1.6 Check gauge readings

At manned stations where a SAMOS system was installed the measurement from the TBR in almost all cases became the climate observation. The observer was instructed to make manual measurements from the 5" gauge and send the observation as part of a "check NCM", either by normal telecommunication routes or by manuscript form. At a fully automatic station the caretaker took manual readings from the 5" gauge regularly, though

not necessarily daily. These readings were archived as paper records but not stored in MIDAS.

1.7 Daily rainfall measured by a TBR

Some climate logging systems attached to a TBR produced daily accumulations that were stored in MIDAS. These included some CDLs and Environment Agency loggers. TBR tip times from Agency loggers (NW region) were processed locally or at the Met Office to provide the daily total. These tip times were not archived in MIDAS; but are stored by some of the Environment Agency regions.

Storage in the 'rain_drnl_ob' table:

ID_TYPE	RAIN CLBR for commercial stations with non-standard exposure
ID	Rainfall number of TBR gauge
MET_DOMAIN	AWSDLY for CDL systems
OB_DAY_COUNT	1
OB_END_TIME	0900
PRCP_AMT	To nearest 0.2mm, but 0.5mm for some Agency loggers

2. Early wind recording methods

2.1 Analysis of hourly wind returned on form 6910

Many synoptic stations performed an analysis of the anemograph traces at the end of each month to record values of mean hourly wind and gusts over the hour. The speed, direction and time of the maximum gusts for each hour hourly observation within each 24 hr (00:00 to 00:00) period were included. This was all returned on form 6910 and uploaded onto MIDAS. The last hourly analysis found in the Wind Mean Ob table was 02/01/2007 23:00.

Storage in the 'wind_mean_ob' table:

ID_TYPE	WIND
ID	Wind number
MET_DOMAIN	HWND6910
OB_END_TIME	HH. Is a true mean for the period HH-0 to HH-0
OB_HOUR_COUNT	1
Met Elements	Mean wind speed, mean wind direction, maximum gust speed in hour, direction of maximum gust, time of maximum gust.

2.1 Hourly wind from loggers

The DALE systems (DALE 1 and DALE 2) for logging winds data were used for many years until a network of CDLs become established which have now become the mini MMS sites we have today. Routine climate returns on Met form 6910 generally ceased when DALE was installed and were only used for infilling missing data. The last observation in MIDAS for the DALE System was on the 23/05/2012 13:00.

Storage in the 'wind_mean_ob' table:

ID_TYPE	WIND or CLBN or CLBD (old commercial CDLs)
ID	Wind number
MET_DOMAIN	HWNDAUTO for DALE systems AWSHRLY for CDL systems
OB_END_TIME	HH. Is a true mean for the period HH-0 to HH-0
OB_HOUR_COUNT	1
Met Elements	Mean wind speed, mean wind direction, maximum gust speed in hour, direction of maximum gust, time of maximum gust.

2.2 Run of wind

Some Ordinary Climatological Stations used to report a 24-hour run of wind which was converted into a 24-hour mean wind speed. The last observation in MIDAS for run of wind was 01/12/2010 09:00:00.

Storage in the 'wind_mean_ob' table:

ID_TYPE	DCNN
ID	DCNN number
MET_DOMAIN	DLY3208
OB_END_TIME	0900 (in a few instances other hours between 0800 and 1000)
OB_HOUR_COUNT	24
Met Element	Mean wind speed

3. Early radiation recording methods

3.1 Form R35

Although not recorded anymore these observations can still be found in MIDAS when looking at retrospective data. Radiation observations were returned on form R35

Storage in the 'radt_ob' table

ID_TYPE	DCNN
ID	DCNN number
MET_DOMAIN	DRADR35
OB_TIME	2359
OB_HOUR_COUNT	24
Met Elements	Radiation fluxes

3.2 MODLE sites

Hourly observations of the near surface radiation fluxes are reported from MODLE stations.

Storage in the 'radt_ob' table

ID_TYPE	DCNN
ID	DCNN number
MET_DOMAIN	MODLERAD
OB_TIME	HH
OB_HOUR_COUNT	1
Met Elements	Radiation fluxes

Appendix D: Other early rainfall measurement practices for hourly data

In the past, a station with one or more 5 inch gauges and no other rainfall instrumentation used one of the gauges to record hourly rainfall which was reported in the SREW. A 12-hour total was reported in the NCM, in most cases from a second gauge. A station with a TSR and one or more 5 inch gauges followed the practice above for the SREW and NCM but also returned hourly values on a Metform 7113 at the end of the month from an analysis of the autographic record from the TSR. To ensure consistency with the daily total measured using the 5 inch gauge (and reported in the NCMs), the analysed hourly values were adjusted to ensure that their sum equalled that of the daily total. In other words, the 24 hour total from the 5 inch gauge, which was regarded as the climatological standard, was “time sliced” by the TSR. In MIDAS hourly values of precipitation amount from the 7113 form overwrote the SREW reports received earlier and the precipitation duration was added.

A station with a SSER system connected to a TBR used that gauge for the SREW.

The analysis of TSR records on a 7113 form was discontinued and the 5 inch gauge remained the source of data for the NCM (except in the case of TBR failure when the TSR analysis was used to infill). Hourly totals were derived from SSER tip times and stored in MIDAS, overwriting the SREW; up to 1997 an adjustment was performed, similar to that for the 7113 analysis, which ensured that the 24 hour sum equalled the total from the 5 inch gauge.

A station with a SAMOS system installed used the TBR for the SREW and, in most cases, for the NCM. The analysis of TSR records on a 7113 form was discontinued. Where a SSER system was also at the station the derivation of hourly values was performed, as described above.

Appendix E: Acronyms

CDB	Climate Data Bank
CDL	Climate Data Logger
CODET	Computerised Observation — Data Encoding and Transmission
DALE	Digital Anemograph Logging Equipment
DCNN	Daily Climatological Network Number
ERT	Electrical resistance thermometer
ESAWS	Enhanced Synoptic Weather Station
GTS	Global Telecommunications System
GPCS	General Purpose Computer System
HCM	Hourly Climate Message
hPa	Hectopascal
ID	Identifier
METDB	Meteorological Database
MIDAS	Met Office Integrated Data Archive System
MMS	Meteorological Monitoring System
MSLP	Mean sea level pressure
MTER	Magnetic Tape Event Recorder
NCM	National Climatological Message
OWL	Observers' Weather Log
PRT	Platinum resistance thermometer
RVR	Runway Visual Range
SAMOS	Semi-Automatic Meteorological Observing System
SAWS	Synoptic Weather Station
SIESAWS	Severe Icing Environment Synoptic Weather Station
SRC_ID	Source identifier
SREW	Synoptic Rainfall Europe West
SSER	Solid State Event Recorder
SYNOP	Synoptic Coded weather report
TBR	Tipping Bucket Raingauge
TSR	Tilting Siphon Raingauge
WMO	World Meteorological Organisations
WOW	Weather Observations Website