MA Protocol

AUTOMATIC WEATHER STATION

Aim

Unattended recording of meteorological data

Rationale

Several ECN sites are geographically remote and this severely restricts the possible frequency of meteorological measurements because these sites cannot be visited consistently at intervals of less than a week. Meteorological data collected at frequent intervals over very long periods are needed both for many ECN purposes and also for environmental research programmes associated with ECN. During the last 20 years there have been considerable advances in the technical development of sensors and data logging devices for automatically measuring and recording meteorological data. Equally important has been the increased reliability of these sensing and logging devices. ECN automatic weather stations (AWS) have therefore been configured to measure and record a basic set of meteorological variables which will:

- provide information on temporal changes in these variables,
- aid in the interpretation of other ECN core measurements,
- provide data to support other environmental research at ECN sites.

It is strongly recommended that wherever possible duplicate stations should be installed to measure significant environmental gradients where these may exist within an ECN site.

Method

Equipment

The need to standardise equipment across the network requires the installation of an instrument configured to ECN specifications. The following variables will be recorded at each site at 5-second intervals and stored as hourly summaries on the hour, with the accuracy and resolution given below in brackets:

Wind speed (±1%; 0.1 m s^{-1})
Wind direction (±2°; 1°)
Wet bulb temperature in non-aspirated screen (±0.1°C; 0.1°C)
Dry bulb temperature in non-aspirated screen (±0.1°C; 0.1°C)
Kipp solarimeter (±1%; 1 W m^{-2})
Net all wave radiation (±5%; 1 W m^{-2})
Tipping bucket raingauge (unheated), placed on paving slab, in a ground level pit at exposed upland sites (±5%; 0.5 mm)
Soil temperature, 10 cm under bare soil (±0.1°C; 0.1°C)
Soil temperature, 30 cm under grass (±0.1°C; 0.1°C)
Downward-facing silicon cell, for albedo/snowcover(±5%;1 W m^{-2})
Gypsum block, 20 cm under grass, for soil moisture measurement (±10%; 0.01 bar)
Surface wetness indicator (indicating the number of minutes per hour during which the surface is 'wet') at ground level (±1 min; 1 min).

An independent copy of the logger programme should be kept on site. Raingauges placed in pits should be surrounded by an anti-splash grid.

Location

The AWS is to be sited according to British Meteorological Office site requirements (Meteorological Office 1982), within 500 m of the TSS and close to the manual meteorological instruments (see Figure 4). If for operational reasons the AWS has to be sited more than 500 m from the TSS, this should be agreed in advance by the ECN Central Co-ordination Unit. The maximum permissible distance of the AWS from the TSS is 2 km.

Operation

Installation of the AWS should follow the instructions in Appendix I and Plate 1. Data are to be downloaded to a PC fortnightly, via a storage module, and the station checked according to the procedures provided in Appendix II. The station should be serviced and the sensors calibrated annually. Further notes on maintenance of equipment are also provided in Appendix II. Data quality control should be carried out according to Appendix III.

Time

4 hours/month (field + computer storage)

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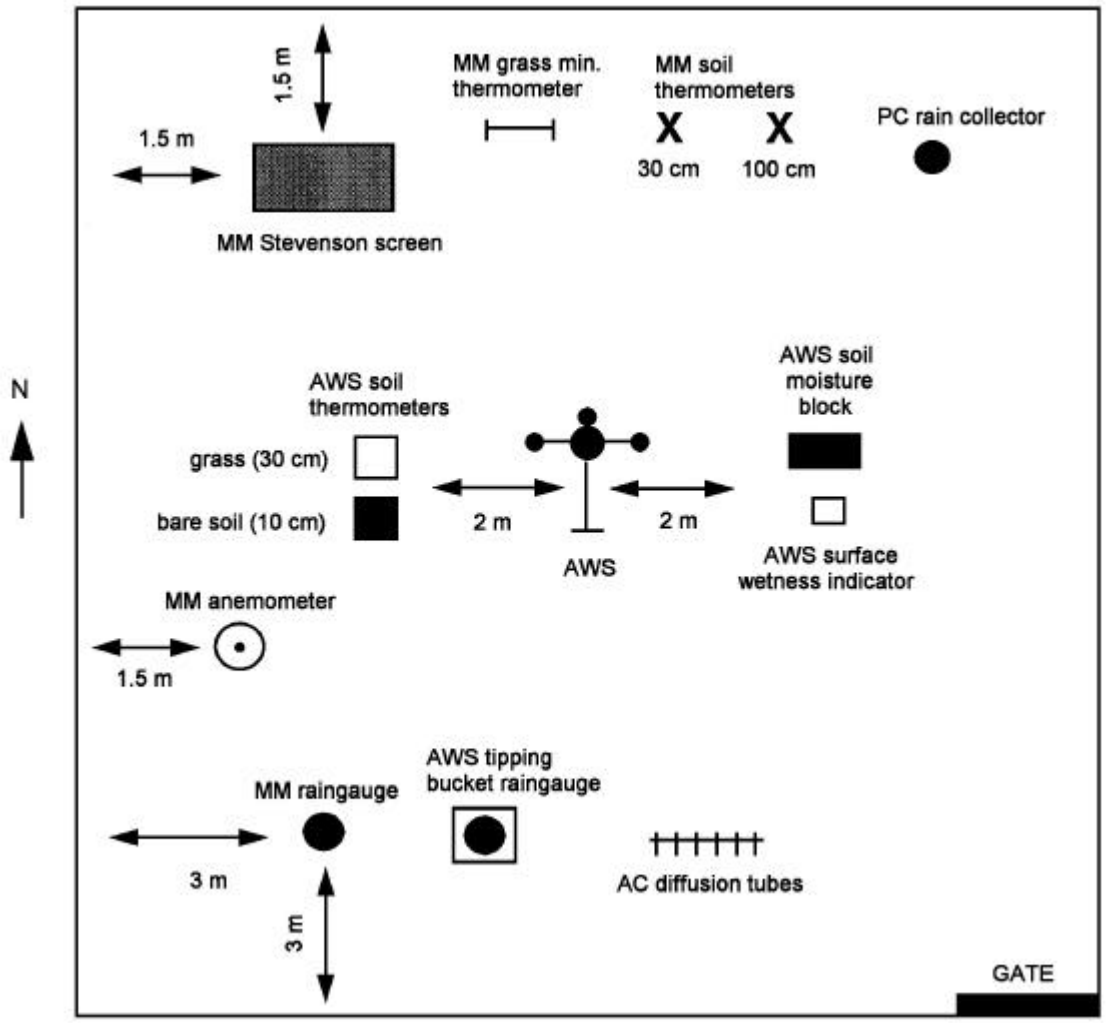

Figure 4. ECN meteorological enclosure

APPENDIX I. Procedure for installing an automatic weather station (AWS)

Procedure

1. Dig a hole large enough to accept the main pole base and approximately 40 cm deep. A concrete base is not normally required unless the soil is particularly unconsolidated.

2. Fix the lower half of the main pole on to its base and lower it into the hole. Keep the pole vertical, using a spirit level, whilst infilling the hole.

3. Lower the bottom cross-arm to the lower half of the main pole.

4. Assemble the solarimeter to the upper half of the main pole using the captive bolt which is in the solarimeter housing. Connect the cable to the solarimeter.

5. Slide the top cross-arm on to the upper half of the main pole and tighten the U-bolt to hold it in place.

6. Fix the top half of the main pole to the lower half.

7. Adjust the height of the top cross-arm to be 2 m above the ground level and oriented east/west.

8. Fix the guy-wires to the top cross-arm and to stakes in the ground, then adjust them so that the main pole is vertical.

9. Slide the lower cross-arm up the main pole to 1 m above ground level and orientated north/south, and tighten the U-bolt to hold it in place.

10. Fit the wind vane, anemometer, temperature screen and sensors, and net radiation sensors to the poles as shown in Plate 1 and connect the cables.

11. Place the raingauge on its concrete base, level the base, using the spirit level in the gauge, by adjusting the feet and connect the cable.

12. Fit the main loom junction box to the main pole using the jubilee clips provided.

13. Connect the sensor cables to the junction box in the correct order. Tape all cables tightly to the cross-arms and main pole.

14. Fit the wick to the wet bulb sensor and fill the reservoir with distilled water.

15. Secure the solar panel to the main pole facing south.

16. Level all sensors and align the wind direction sensor to face north.

17. Install the logger in its housing and connect the main cable to the logger.

18. Hammer the earth rod into the ground and connect the earth-braided wire to the earth rod and stud on the logger.

19. Connect the solar panel cable to the logger.

20. Connect the storage module to the logger to download.

21. Close the logger.

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Notes

The soil temperature probes should be installed to the west of the main mast, at least 2 m away from it or as far from it as the cable supplied will allow.

The albedometer should be mounted 1 m above the ground in a roughly SSE direction from the main mast, ie as close to south as possible without interfering with the net radiometer.

The soil moisture block should be installed to the east of the main mast, at least 2 m away from it or as far as the cable supplied will allow.

The surface wetness indicator should be installed on a representative piece of ground to the east of the main mast, at least 2 m away from it or as far as the cable supplied will allow.

The only parts not supplied with the AWS by the manufacturer are a concrete slab for the raingauge base and a suitable weatherproof housing for the logger.

APPENDIX II. Notes on maintenance of AWS equipment

1. The grid on the surface wetness indicator should be cleaned regularly, preferably on each fortnightly visit to the AWS, with a soft cloth and mild household detergent.

2. The wick on the temperature probe should be checked for dampness and contamination and be replaced if necessary; 3-12 month intervals are recommended depending on the environment. Wet bulb reservoirs should be topped up fortnightly with distilled water.

3. Net radiometer domes should be checked for cleanliness or damage every six months. The silica gel should be changed if necessary.

4. The solar dome should be cleaned fortnightly and the silica gel changed if necessary.

5. Gypsum blocks are destroyed by frost; under most circumstances likely to be met in ECN they should be unaffected at a depth of 20 cm, but should be replaced if there is a likelihood of there having been frost at this depth. They should in any case be replaced annually in spring.

6. The logger output should include a daily reading of battery voltage. Check that the battery voltage is not outside the range 11.5-14 volts. If the voltage falls outside the level recommended by the manufacturer, the batteries should be replaced. Batteries should in any case be replaced every two years. Note that an external battery must be connected to preserve the software when replacing the internal battery.

7. Check that the anemometer and wind vane rotate freely. Change the anemometer reed switches annually at exposed sites.

8. Check that the raingauge funnel and filter are free of debris, snow and ice. Clear any ice from the tipping buckets (without making a tip). Check that the base is level using a spirit level on the base, and adjust the feet if necessary.

9. Check that no cables are perished or damaged by animals and replace if necessary.

10. Check the effectiveness of the guy wires supporting the mast.

11. Check the security of the earthing cable and rod.

APPENDIX III. Procedure for quality control of AWS data

1. Check that the first and last data points agree with the times of data removal from the logger.

2. Check that the dry and wet bulb observations from the manual station agree with logger data, remembering that the logger gives a mean value for the last complete hour of recording.

3. Check that the rainfall total for the manual station agrees with amounts recorded by the logger by adding the daily logger totals to the hourly values for the days on which the logger has been downloaded.

4. If defective equipment has been noted during a field visit, identify erroneous data on the logger output and note the date ranges of errors for the information of the ECN Data Manager.

5. Check the output for missing data or unusual sequences of values, eg a series of constant values may appear when a variable series is expected. This may denote faulty sensors. If a sensor has been removed for repair, a missing data value, to be agreed with the ECN Data Manager, should appear in the logger output. Note any occasions when freezing may have affected sensors.

6. Make notes on the results of all checks, and any changes which are necessary or have been made and ensure that these notes accompany the data when they are transmitted to the ECN Data Manager.

Specification of results and recording conventions

The measurement variables listed below are those required for each MA sampling location at an ECN Site. Sites submitting data to the ECNCCU should refer to the accompanying Data Transfer documentation for the specification of ECN dataset formats, available on the restricted access Site Managers' extranet. Contact ecnccu@ceh.ac.uk if you need access to this documentation.

The first 4 key parameters uniquely identify a sample or recording occasion in space and time, and must be included within all datasets:

• Site Identification Code (e.g. T05)	Unique code for each ECN Site
• Core Measurement Code (e.g. PC)	Unique code for each ECN 'core measurement'
• Location Code (e.g. 01)	Each ECN Site allocates its own code to replicate sampling locations for each core measurement (e.g. for different surface water collection points)
• Sampling Date (/time)	Date on which sample was collected or data recorded. This will include a time element where sampling is more frequent than daily

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Core measurement: meteorology – automatic weather station (MA Protocol)

The following variables are recorded hourly for each automatic weather station and automatically logged.

Variable	Units	Precision of recording
Site Identification Code		
Core Measurement Code		
Location Code		
Year		
Day number	Julian within year	
Hour	GMT 24-h clock	1 h
Solar radiation (average)	W m^{-2}	1
Net radiation (average)	W m^{-2}	1
Wet bulb temperature (average)	°C	0.1
Dry bulb temperature	°C	0.1
Wind speed (average)	m s^{-2}	0.1
Wind direction (average)	degrees	1
Rainfall (total)	mm	0.1
Albedo - ground (average)	W m^{-2}	1
Soil temperature at 10 cm (average)	°C	0.1
Soil temperature at 30 cm (average)	°C	0.1
Surface wetness (total time wetness <0.8)	min	1
Soil water potential (average)	bars	0.01