ECN Technical Note 4

AWS Operation

Background

Automatic Weather Station management and maintenance have differed between ECN sites in the past, with potential impacts on the quality of the data being gathered. This document has grown from the Special Topic Workshop held during the 2004 Site Managers Meeting and it aims to unify AWS operation across the ECN sites and further improve the quality of ECN AWS data. Technological and other developments make it essential that this technical notes is constantly updated and developed.

Fortnightly AWS Downloading

The ECN protocol requires that the AWS is downloaded at a maximum of fortnightly intervals. Although the logger can hold much longer periods of data this frequency is specified because downloading is the best way of determining if the logger is still functioning and frequent downloading ensures that any down-time is kept to a minimum. Immediately after each download the data should be examined to see that all sensors are functioning so that any repairs can be initiated immediately.

Fortnightly AWS Maintenance

Once per fortnight, usually after the downloading, a range maintenance tasks should be undertaken by site staff to ensure that AWS remains in optimum condition. Any problems encountered should be recorded and sent to the CCU with the data. These activities are given in Appendix 1 and require only a minimum of training.

Monthly Data Quality Check

It is very important that site staff check the quality of their AWS data because with knowledge of field conditions and only a little experience it is possible to identify problems as soon as they occur. Although the ECN CCU also runs quality checks on the data, site staff should regard these as a final check only and not rely on it for their own quality control. The CCU checks often take place a considerable time after data collection, by which time the AWS may have been recording in error for some months, and site staff are much better placed than the CCU to deal with individual site AWS problems and corrective actions.

The data checks should cover a one week period close to the end of the month which may be selected to coincide with the period of an adjacent manual weather station. Ideally the ECN AWS (ECN Protocol MA) should be co-located with a manual weather station recorded at a minimum interval of weekly (ECN Protocol MM) but comparison with other stations in the vicinity is better than nothing. Suggested monthly data quality checks are given in Appendix 2.

Once problems are identified they should be dealt with immediately to reduce data loss.

Annual AWS Service

AWSs should be fully serviced once a year according to the guidelines in Appendix 3. As this requires a range of skills including engineering knowledge and a full understanding of logger programmes it will normally be necessary to employ an instrument engineer. The ECN CCU will inform sites when their AWSs need servicing and the interval between services should never exceed two years. Receipt by the CCU of the engineers report and a copy of the modified logger programme will confirm that the service has taken place.

CEH Wallingford can undertake these services but they are required to charge commercial rates. As travel costs and time (and thus cost) can be considerable from Wallingford (Oxfordshire) to many ECN sites CEH Lancaster (Lancashire) and Macaulay Institute (Aberdeen) also offer a similar service for central and northern UK sites. Contact details are given in Appendix 5.

Site staff should accompany service engineers when they work on an AWS. Engineers are usually very willing to guide staff in AWS operation and point out problems. Also having site staff present removes the cost of engineers having to "double-man" for safety reasons.

Breakdowns and Faults

Site visits by instrument engineers to repair faults incur the same heavy costs as servicing visits. To reduce the cost of these, sensors can be posted to CEH instrument engineers or ideally back to the manufacturers for repair and calibration. Sites are encouraged to carry a range of spare sensors to reduce down-time.

Training

With only a slow turn-over of ECN field staff it is unlikely to be worthwhile organising a course in routine operation of AWSs. When new staff are appointed without any possibility of training from existing colleagues the CCU should be contacted. The CCU will arrange training in routine operation, probably from an experienced site manager. More advanced training, if required, should be arranged with instrument engineers when they visit sites for AWS servicing.

UK Joint Code of Practice for Research

The date and time of any maintenance or data checks and any problems encountered should be recorded in line with the UK Joint Code of Practice for Research.

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2 February 2006

Appendix 1. Fortnightly Maintenance

Appendix 1a AWS equipped and configured according to ECN's original specification

1. Clean surface Kipp solarimeter, albedometer (top and bottom) and solar panel with a soft cloth and a little household detergent. Check for damage.

2. If dry, clean surface wetness sensor with a soft cloth and a little household detergent. Check for damage.

3. Check wick of wet bulb temperature sensor for dampness and contamination - change if necessary.

4. Top up wet bulb reservoir with deionised water.

5. Check silica gel in Kipp solarimeter and if pinkish replace. This might require some steps or a mirror on a stick to check the dome on the top of the sensor for signs of moisture.

6. Check both domes of net radiometer for damage or wetness inside – bring back sensor for repair if necessary.

7. Check that the anemometer and wind vane rotate freely.

8. Check that soil above 10 cm temp probes is weed free and compact.

9. Check that grass is clear of surface wetness sensor which should be close to the ground at angle of 45 degrees with a northerly aspect.

10. Check the raingauge for debris - remove funnel without making any tips and rinse clean if necessary. NB snow and ice should be left in funnel to melt.

11. Check tripod and guy wires for damage. Ensure U -bolts and sensors are firmly attached

12. Replace AWS desiccant bags with fresh ones.

Appendix 1b, AWS equipped and configured according to ECN's new specification

1. Clean surfaces of upward and downward Kipp solarimeters, and solar panel with a soft cloth and a little household detergent. Check for damage to leads and sensors.

2. If dry, clean surface wetness sensor with a soft cloth and a little household detergent. Check for damage to lead and sensor.

3. Check silica gel in Kipp solarimeters and if pinkish replace. This might require some steps or a mirror on a stick to check the dome on the top of the sensor for signs of moisture.

4. Check both domes of net radiometer for damage or contamination. Careful cleaning may be required. Check lead for damage.

5. Check that the anemometer and wind vane rotate freely. Note if the anemometer is noisy at high wind speed or fails to rotate in a light breeze.

6. Check that soil above 10 cm temp probes is weed free and compact.

7. The surface wetness sensor should be close to the ground at angle of 45 degrees with a northerly aspect. Remove any grass blades touching or close to it.

8. Clean any white sensor housings, e.g. RH, if they are obviously dirty.

9. Check the rain-gauge for debris. Remove the funnel without making any tips and rinse clean if necessary. Note: snow and ice should be left in funnel to melt.

10. Check tripod and guy wires for damage. Ensure U -bolts and sensors are firmly attached

11. Replace AWS desiccant bags with fresh ones.

Appendix 1c, AWS equipped and configured according to ECN's specification for ECN Biodiversity Network

1. Clean surfaces of Kipp solarimeter (if present), and solar panel with a soft cloth and a little household detergent. Check for damage to leads and sensor.

2. Check silica gel in Kipp solarimeter (if present) and if pinkish replace. This might require some steps or a mirror on a stick to check the dome on the top of the sensor for signs of moisture.

3. Check both domes of net radiometer for damage or contamination (if present). Careful cleaning may be required. Check lead for damage.

4. Check that the anemometer and wind vane rotate freely. Note if the anemometer is noisy at high wind speed or fails to rotate in a light breeze.

5. Check that soil above 10 cm temp probe (if present) is weed free and compact.

6. Clean any white sensor housings, e.g. RH, if they are obviously dirty.

7. Check the rain-gauge for debris. Remove the funnel without making any tips and rinse clean if necessary. Note: snow and ice should be left in funnel to melt.

8. Check tripod and guy wires for damage. Ensure U -bolts and sensors are firmly attached

9. Replace AWS desiccant bags with fresh ones.

Appendix 2. Monthly data quality check

The examples below assume an AWS is being compared with weekly manual met recordings from a co-located manual station. However similar checks can be made based on a nearby automatic station or indeed, if appropriate allowances are made, a more distant manual or automatic station. This list is written for a full ECN original specification AWS so not all these checks will be relevant for instance to an ECN Biodiversity Network AWS.

1. **Graph the data from all four temperature sensors for the test week.** The wet bulb air sensor should always be similar to or less than the dry bulb sensor. The 10 cm soil temperature sensor should show less daily variation than air temperature and its peaks and troughs should lag behind the air temperature peaks and troughs. The 30 cm soil temperature sensor should show less daily variation than the 10 cm sensor and its peaks and troughs may bear only a vague relationship with air temperature.

2. **Graph the data from the three light sensors for the test week.** Highest values should come from the Kipp Solarimeter. Lowest values should come from the albedometer ground sensor. The Kipp, the albedometer sky and the albedometer ground sensors should all register close to zero at night. During clear nights the net solarimeter should record negative values.

3. **Graph rainfall and surface wetness data for the test week.** If the surface wetness sensor does not record when there is rain there is a problem. However it may register when there is no rain, usually as a result of night-time dew.

4. **Graph rainfall and soil moisture data for the test week.** Look for evidence of the soil moisture responding to periods without rain (which will be more marked in summer when plants are actively respiring).

5. **Compare the sum of the rainfall for the test week with weekly value from the manual met**. Good agreement is usually found except when snow has fallen in the test week so if possible avoid snowy weeks.

6. **Compare the maximum temperature recorded by the AWS in the test week with the figure from the manual maximum thermometer.** Variation will often be less than 1 degree.

7. **Compare the minimum temperature recorded by the AWS in the test week with the figure from the manual minimum thermometer.** Variation will often be less than 1 degree.

8. **Compare run of wind recorded from the manual anemometer with that from the AWS.** As the AWS records wind velocity in metres per second this has to be converted to kilometres. To do this multiply the average velocity for the week by the number of days and by 86.4.

Appendix 3. Annual Servicing

This list is written for a full ECN original specification AWS so not all these checks will be relevant for instance to an ECN Biodiversity Network AWS.

Logger
Inspect for good condition and in particular for signs of damp ingress.
Download data and programme and check if they meet the ECN protocol.
Check and adjust time kept by AWS (it should always operate in GMT).
Check tightness of sensor lead terminal screws on logger.

Power Supply
Inspect solar panel, ensure correct orientation and check output.
Replace battery if old and/or in poor condition.
Check (from data) for correct voltage regulation and replace regulator if required.

Mast
Inspect securing points and cables and replace if necessary. Lubricate screws and fastenings if necessary.
Set mast vertical with correct North orientation.

Rain Gauge
Ensure funnel filter, tipping bucket and tipping bearing points are clean and in good order.
Adjust cover clamps and base adjustment screws to ensure all are level.

Solarimeter
Ensure it is mounted horizontally without obstruction to light capture.
Check calibration against a similar sensor that has itself been recently recalibrated by the manufacturer and adjust logger programme accordingly.*

Net radiometer
Ensure it is mounted horizontally without obstruction to light capture.
Check calibration against a similar sensor that has itself been recently recalibrated by the manufacturer and adjust logger programme accordingly.*

Albedometer
Ensure it is mounted horizontally without obstruction to light capture.

Wet/dry bulb hydrometer
Remove temperature probes, check calibration in stirred crushed ice and amend programme if necessary.
Replace water reservoir if badly bowed due to freezing of contents.
Lubricate probe fastening screws and correctly re-align probes. Clean outer housing.

Wind speed
Check for wear, noisy bearings, freedom of movement, vertical alignment.

Wind direction
Check for wear, noisy bearings, freedom of movement, vertical and northerly alignment.

Soil temperature probes
The ECN protocol requires the 10 cm probe to be under bare ground and the 30 cm probe under grass. If readings are not in doubt check that the 10 cm probe is still at 10 cm ie that the soil has not been eroded from above the probe. Add more soil if necessary and gently compact it.

If readings are in doubt, dig up and test - check calibration in stirred crushed ice and amend programme if necessary. Re-install probes horizontally at correct depths. If the probes are damaged it will be best to replace them.

Soil moisture probe
If readings are in doubt, dig up and test. Re-install or replace horizontally at correct depth which is 20 cm below grass.

Surface wetness probe
Visually inspect and check programming method. The probe should be at ground level and inclined at 45 degrees.

Reporting
The servicing engineer will complete a report for the site manager on problems encountered and adjustments made. This report and a copy of the modified logger programme should be sent to the CCU for archiving.

* CEH Lancaster do not currently have the equipment to check the calibration of these two sensors. However an alternative would be to send them back to the manufacturers for calibration.

Appendix 4 – Logger Data Format (see also ECN Data Transfer Format for AWS data)

Data Column	Data Column Name	Units	Hourly	Older-Style AWS	New-Style AWS	Biodiversity AWS
1	Year			Yes	Yes	Yes
2	Day	Julian		Yes	Yes	Yes
3	Hour	GMT, 24 hr clock		Yes	Yes	Yes
4	Solar radiation from upward Kipp	W m^{-2}	Average	Yes	Yes	Desirable or -6999
5	Net radiation	W m^{-2}	Average	Yes	Yes	Desirable or -6999
6	Wet bulb air temperature	Celsius	Average	Yes	-6999	-6999
7	Dry bulb air temperature	Celsius	Average	Yes	Yes	Yes
8	Wind speed	m sec^{-1}	Average	Yes	Yes	Yes
9	Wind direction	degrees from N	Average	Yes	Yes	Yes
10	Rainfall	mm	Total	Yes	Yes	Yes
11	Albedo sky (same as 4 in New Style AWS)	W m^{-2}	Average	Yes	Yes	-6999
12	Albedo ground (downward Kipp in New Style AWS)	W m^{-2}	Average	Yes	Yes	-6999
13	Soil temp. at 10cm under bare ground	Celsius	Average	Yes	Yes	Desirable or -6999
14	Soil temp. at 30cm under grass	Celsius	Average	Yes	Yes	-6999
15	Surface wetness	mins in hour < 0.8	Total	Yes	Yes	-6999
16	Soil water content at 20 cm	%	Average	Yes	Yes	-6999
17	Relative humidity by RH sensor	%	Average		Yes	Yes
18	Dry bulb air temperature in RH screen	Celsius	Average		Yes	Yes
19	Grass temperature	Celsius	Minimum		Yes	

The last column of data on any logger should always be the hourly average battery voltage as a check on the AWS. This is not sent to the CCU.
An "Older-Style AWS" logger should record 17 columns including the voltage column.
A "New-Style" logger should record 20 columns including the voltage column and one column filled with -6999s.
A "Biodiversity AWS" should have a min of the six sensors specified. Other sensors are desirable but if these are not present -6999s should be used instead.
A "Biodiversity AWS" logger should record 19 columns including the voltage column and up to nine columns filled with -6999s.
A new network is being planned, the Targeted Monitoring Network, which may replace the Biodiversity Network and specifications may therefore change.

Appendix 5 – AWS Service Contacts

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