A Review of SIRS Data Quality at the ARM Southern Great Plains Site

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Introduction

The Atmospheric Radiation Measurement (ARM) Program needs high-quality broadband shortwave (solar) irradiance information for the development and validation of atmospheric circulation and climate models. To that end, the National Renewable Energy Laboratory (NREL) performs a quality assessment of the data from 22 Solar Infrared Radiation Stations (SIRS) in the Southern Great Plains (SGP) on a month-by-month, site-by-site basis. Up to 16 months of data from the SIRS instrument platform is now available for many SGP sites. This makes possible an assessment of data quality for the entire SGP network over the span of several months. Individual site performance can be compared to overall network performance, and to other individual sites. This paper summarizes the availability and quality of broadband shortwave and longwave irradiance data collected by the SIRS for the year 1998.

Approach

The quality of shortwave solar radiation data can be determined using a suite of tests in a program called SERI_QC,[a] developed at NREL. Augustyn & Co.'s Data Quality Management System (DQMS) runs SERI_QC on each data point, and assigns to a flag indicating the test passed or failed, and the degree of failure (see Table 1).

Although algorithms can be written to test the quality of longwave (atmospheric) radiation data, as yet no code exists to run these tests on the data point-by-point and assign flags, similar to the shortwave assessments. At present, longwave radiometric data are visually inspected, and any problems found in the data are reported. Augustyn & Co. has proposed the inclusion of tests and flagging for longwave solar radiometric data to the next version of DQMS allowing the data quality of the longwave radiation data to be determined quantitatively.

Similarly, the quality of upwelling shortwave data is not automatically tested. The diurnal plots are examined visually and any anomalies found in the upwelling shortwave trace lead to closer inspection of the data itself. The proposed upgrade of DQMS will include iterative tests on upwelling shortwave radiation.

(a) See *Quality Assessment with SERI_QC*, http://rredc.nrel.gov/solar/pubs/seri_qc/.

Table 1. Flagging convention for SERI_QC.

Flag	Description
00	Untested (raw data)
01	Passed one-component test; data fall within max-min limits of Kt, Kn, or Kd
02	Passed two-component test; data fall within 0.03 of the Gompertz boundaries
03	Passed three-component test; data come within +0.03 of satisfying Kt = Kn + Kd
04	Passed visual inspection; not used by SERI_QC1
05	Failed visual inspection; not used by SERI_QC1
06	Value estimated; passes all pertinent SERI_QCl tests
07	Failed one-component test; lower than allowed minimum
08	Failed one-component test; higher than allowed maximum
09	Passed three-component test but failed two-component test by >0.05
10-93	Failed two- or three-component tests in one of four ways To determine the test failed and the manner of failure (high or low), examine the remainder of the calculation (flag + 2)/4. **Rem** **Failure** 0 Parameter too low by three-component test (Kt = Kn + Kd) 1 Parameter too high by three-component test (Kt = Kn + Kd) 2 Parameter too low by two-component test (Gompertz boundary) 3 Parameter too high by two-component test (Gompertz boundary) The magnitude of the test failure (distance in K-units) is determined from d = (INT (flag + 2)/4)/100 Examples and further discussion of the meaning of flags 10-93 are given in the Users Manual for SERI QC Software in Chapter 6 and in Section 9.3, page 153.
94-97	Data fall into a physically impossible region where Kn > Kt by K-space distances of 0.05 to 0.10 (94), 0.10 to 0.15 (95), 0.15 to 0.20 (96), and >0.20 (97).
98	Not used
99	Missing data

Results

Overall, shortwave solar radiometric data quality for the SIRS SGP network in 1998 is good (see Figure 1), perhaps better than might be expected from a network of sites receiving maintenance only once every two weeks. Typical problems encountered are failed solar trackers, often due to power failures, loss of data (see Figure 2), smudged or dirty domes on the pyranometers, and possible grounding problems. The first of these is virtually self-correcting; once power is again available to the unit, the tracker runs through a self-test and repositions itself on the sun. The second is largely a product

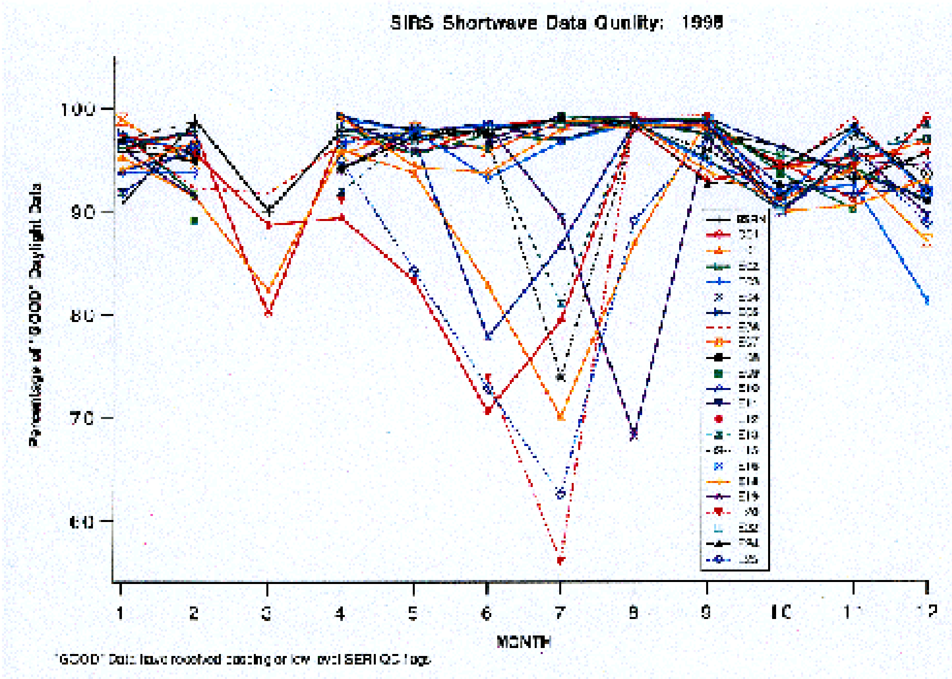

Figure 1. The percent of present daytime data for each site-month receiving passing or low-level SERI_QC flags.

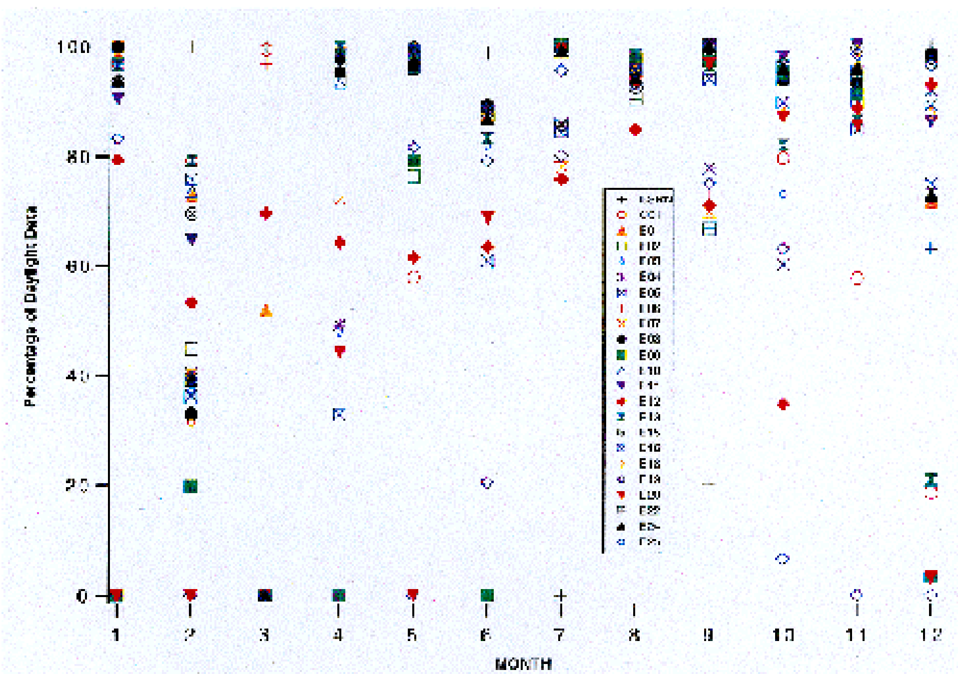

Figure 2. The percent of possible daytime shortwave data by site-month used in the data quality analysis presented here.

of the Site Data System call schedule and has, for the most part, been eliminated. Additionally, the so-called "Sneakernet" data storage cards provide a nearly fool-proof backup data acquisition system. The third problem is a result of the two-week maintenance schedule; and, therefore little can be done to correct it. As for the fourth issue, most electrical grounding problems have been resolved or are being corrected. Figure 3 shows a monthly quality assessment summary for July 1998.

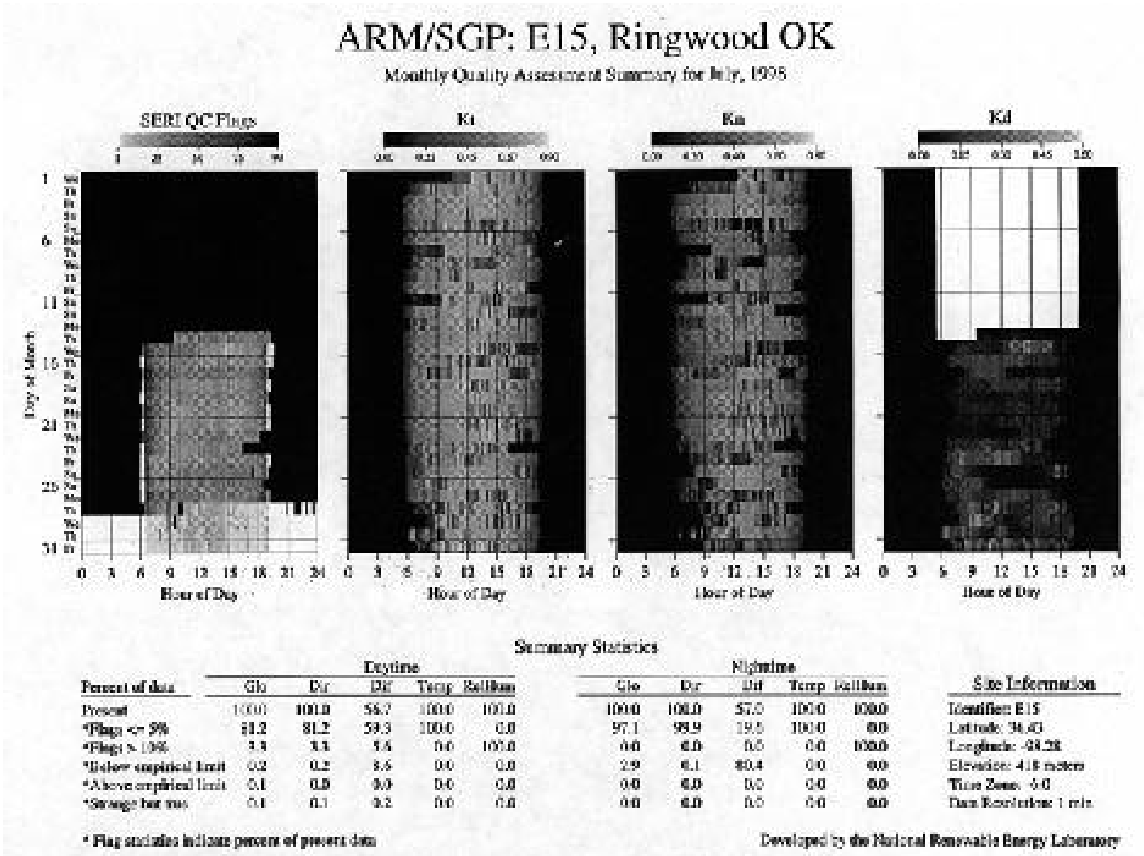

Figure 3. The percentages represented in Figures 1 and 2 are averages of the percentages for the individual downwelling shortwave components. Above, we see that although the daytime statistics for the downwelling shortwave (Glo) and the direct normal shortwave (Dir) are good, those for the diffuse shortwave (Dif) will drag the average down. For this site-month daytime data present is 85.6%, and "good" data is 73.9% of the present daytime data.

Figures 4 through 8 demonstrate some of the dubious features seen in the downwelling and upwelling longwave signals in 1998.

- In Figure 4, a 1-minute "spike" seen at 2359 Greenwich Mean Time (GMT) (17:59 CST) in the longwave and shortwave signals. This spike is seen at several SGP SIRS sites and is, as yet, unexplained. It may occur in both longwave and all four shortwave signals, or in only a few of these. It is of varying amplitude and is always positive in the shortwave, but may be negative or positive in the longwave signals.

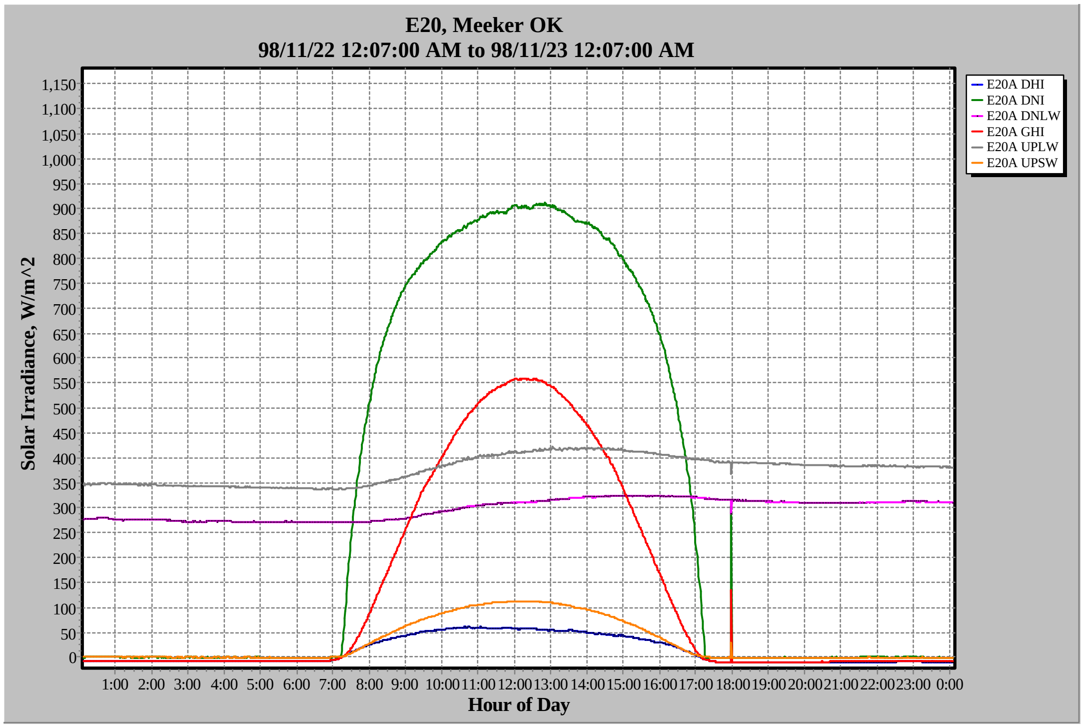

Figure 4. A 1-minute "spike" seen at 2359 GMT (17:59 CST) in the longwave and shortwave signals.

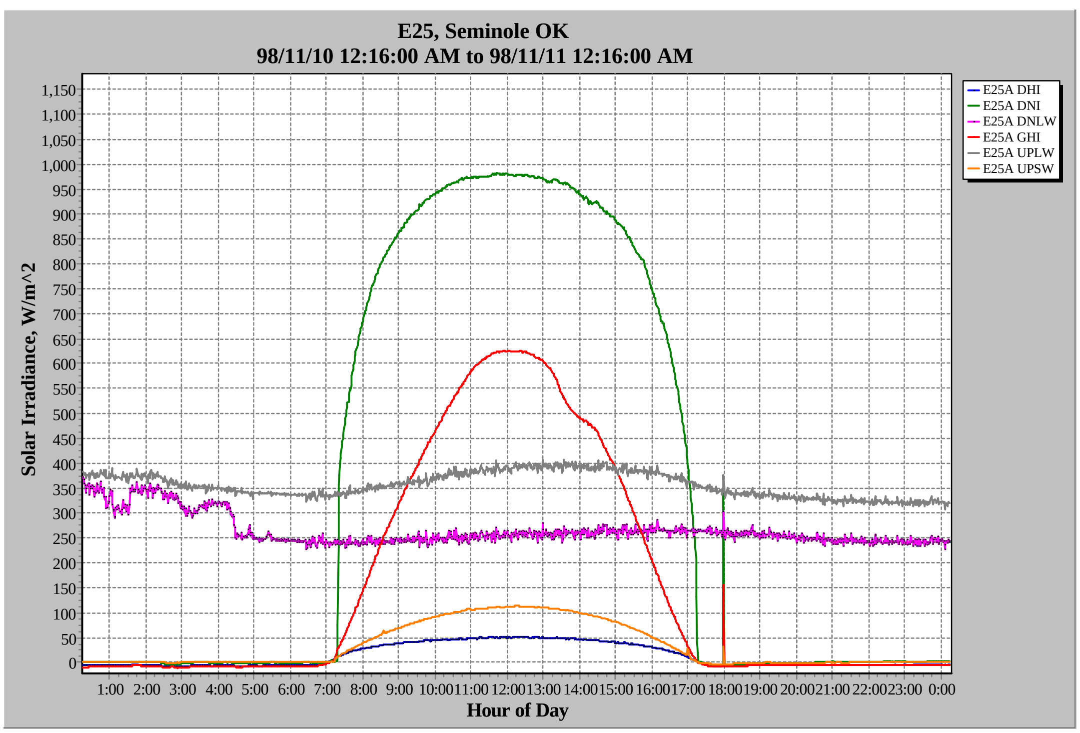

Figure 5. Noise in both longwave signals is evident in this diurnal plot.

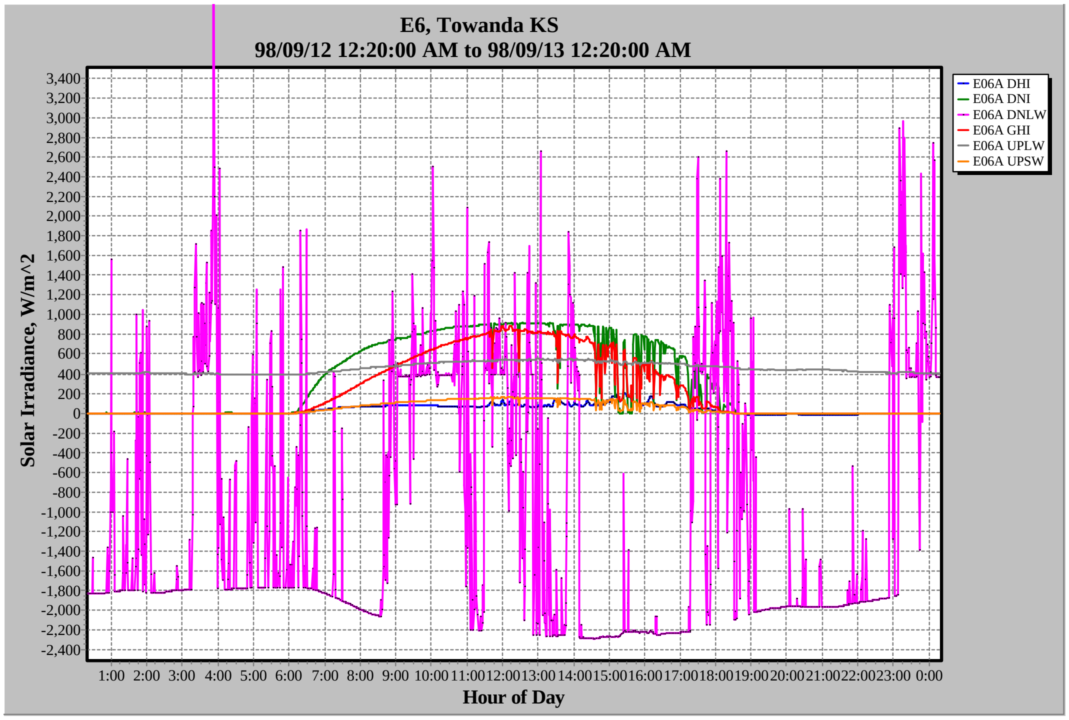

Figure 6. Large spikes, both positive and negative, are observed in one or both longwave signals at three SIRS sites.

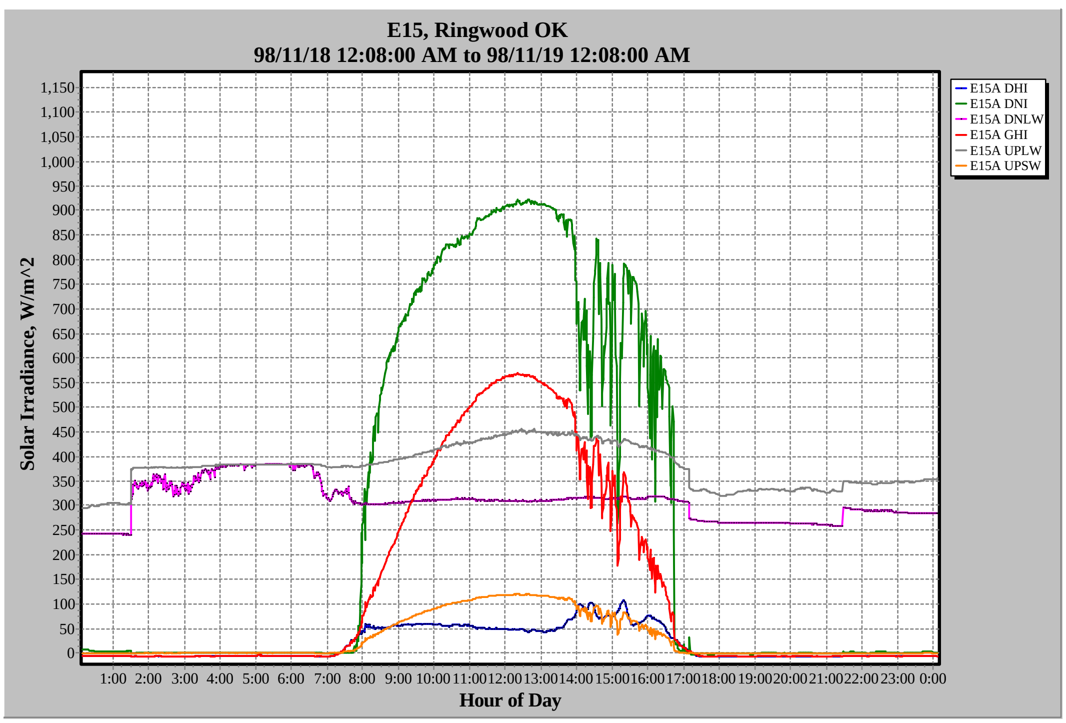

Figure 7. A “step” up or down in the longwave signals, and perhaps appearing in the shortwave signals is observed at several SIRS sites in the fall of 1998.

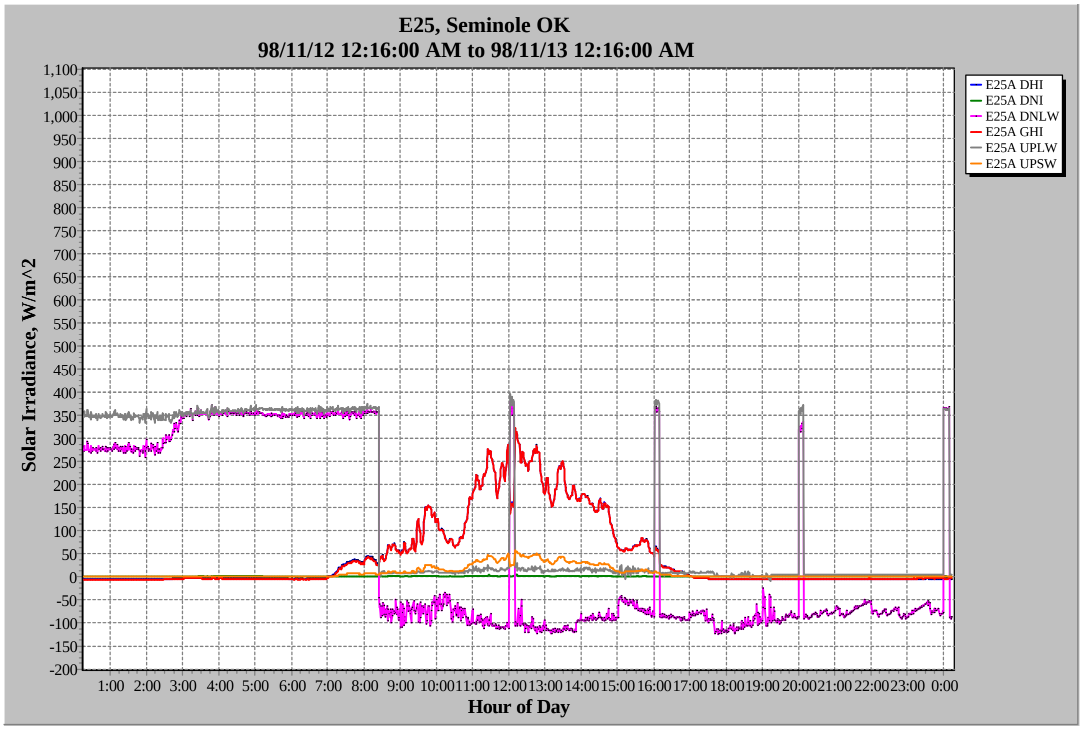

Figure 8. Along with noise in the longwave signals, E25 (Seminole, Oklahoma) experienced a periodic pulse in the longwave signals as early as October 1998.

- Noise in both longwave signals is evident in the diurnal plot of Figure 5. The cause has not yet been determined. The distorted downwelling shortwave (GHI) curve indicates that the dome of the unshaded Precision Spectral Pyranometer may be dirty on the side facing west. The 1-minute spike seen in Figure 4 can also be observed.

- In Figure 6, large spikes, both positive and negative, are observed in one or both longwave signals at three SIRS sites. Additionally, one or both signals may appear at times to have been shifted downward. At E24 (Cyril, Oklahoma) the spikes disappeared in mid-November after a loose connection to a resistor in the multiplexer was tightened.

- A "step" up or down in the longwave signals, and perhaps appearing in the shortwave signals can be seen in Figure 7. Similar "steps" were observed in the data from several SIRS sites in the fall of 1998. The step in the signal or signals appears to occur at approximately the time the data collection call at each site is initiated. The return step is seen at the time of the next call. The steps are no longer seen at most sites since preventive maintenance was performed in early December. It is suspected that signal cables to the data logger were loose, and that the data collection signal sent to the data logger caused the step up or down in the signals. These loose connectors were then properly tightened during the preventive maintenance.

- Along with noise in the longwave signals, E25 (Seminole, Oklahoma) experienced a periodic pulse in the longwave signals as early as October 1998, as illustrated in Figure 8. This pulse, occurring approximately every 4 hours and lasting for approximately 8 minutes, may coincide with the data collection calls to this site. Both longwave and shortwave “regular delivery” data is missing in between these 8-minute pulses. Sneakernet data, however, is filled in between the pulses.

Conclusions

A regular and timely data quality assessment is an important element of controlling the quality of measurements. The quality of SIRS data collected in 1998 is consistent with the scheduled maintenance (two-week cycle) and radiometer calibration (annual) practices. NREL will continue use the DQMS software to automatically determine SIRS data quality and prepare ARM Data Quality Reports (DQRs).