Near Real-Time Assessment of SWATS Data Quality, Resulting in an Overall Improvement in Present-Day SWATS Data Quality

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Introduction

The Soil Water And Temperature System (SWATS) has been an important instrument platform for the interaction of the Atmospheric Radiation Measurement (ARM) Program with other federally funded programs. The deployment of the SWATS to 21 ARM Southern Great Plains (SGP) extended facilities (EFs) was funded in part by the Global Energy and Water Experiment (GEWEX) Continental-Scale International Project (GCIP) and partial funding from the U.S. Department of Agriculture (USDA) for the El Reno EF. The importance of the SWATS data in conjunction with these other agencies is apparent, for example, the soil sampling activity of the SGP ´97 Hydrology Intensive Observation Period (IOP), and anticipation of a similar campaign in 1999. Therefore, it is of great importance to qualify the quality of the data being produced from the SWATS instruments. This is done in part by the cooperation of the SWATS mentor and the ARM SGP site scientist team (SST).

Performance Metrics

In an effort to develop a systematic, integrated view of the quality of the SGP data streams over the long-term, the SST in February of 1996 began routine monitoring of SGP instruments through the criterion and analysis of data quality performance metrics. These metrics determine the percentage of data values that fall within specified (by instrument mentors, factory recommendations, the SST, etc.) quality tolerances. These tolerances include MIN, MAX, and DELTA checks. The tolerances for the SWATS are specified in Table 1.

Table 1. The specified quality tolerances for each of the variables measured by the SWATS platform. These tolerances include MIN, MAX, and DELTA checks.

Variable	MIN/MAX	DELTA
Reference temperature	-25/50 (°C)	20 (°C)
Soil temperature	-20/50 (°C)	20 (°C)
Temperature rise	1.0/4.5 (°C)	3.5 (°C)
Soil water potential	-7000/0 (kPa)	7000 (kPa)
Water content	0/0.55 (m^3/m^3)	0.55 (m^3/m^3)

Data Quality Graphical Displays

Data quality graphical displays are intended to provide a tool for the near real-time assessment of instrument data quality. These displays are produced to condense the information produced from the performance metrics. The automated production of these displays provides the tool for near-real time assessment of the health and status of the instrument data stream. The SWATS data quality graphical displays were produced with the ARM Information Architecture/Meta Data Navigator (AIA/MDN) concept in mind. First, the availability of data is represented. If no data is available, black will be used to represent data quality status. Good data is represented with the color green, suspect data yellow, and poor data red**.** The context of good, suspect, and poor data is represented in the following manner. If the amount of data for a day, is both in existence and is not flagged by the performance metric MIN, MAX, DELTA check; is >90%, then it is marked good (green), 80%-90% suspect (yellow), and <80% poor (red). The images in Figure 1 are snapshots of the data quality graphical displays currently being produced by the ARM SGP SST. The URL of these images is *www.res.sgp.arm.gov/sst/dq_monitor/swats.html*.

Figure 1 illustrates the data quality graphical displays available on the World Wide Web. The top two images (a and b) represent the passing percentages generated by the performance metrics for each of the SWATS variables in both the East and West profiles. These passing percentages represent the sum total of all measurements passing at all levels in the profile. This does not give any indication as to which sensor(s) are having difficulties. It is evident that during January 12 through 19, the SWATS at LeRoy, Kansas, is having poor and suspect passing percentages for the temperature rise, soil water potential, and water content variables.

The next two images in Figure 1 (c and d) represent the passing percentages generated by the performance metrics for each of the SWATS variables at each sensor depth in both the East and West profiles. Images a and d only give a gross indication of problems, but these images provide the information on which sensors are having problems. During this same period, January 12-19, 1999, at Leroy, Kansas, it is clearly evident from these data quality displays that only the 5-cm and 15-cm sensors are contributing to the poor data quality illustrated in images a and b. Corrective maintenance by SGP site operations on January 20 found loose connections to the multiplexer. Passing percentages of 100%, evident on January 21, are apparent after the corrective maintenance performed on January 20.

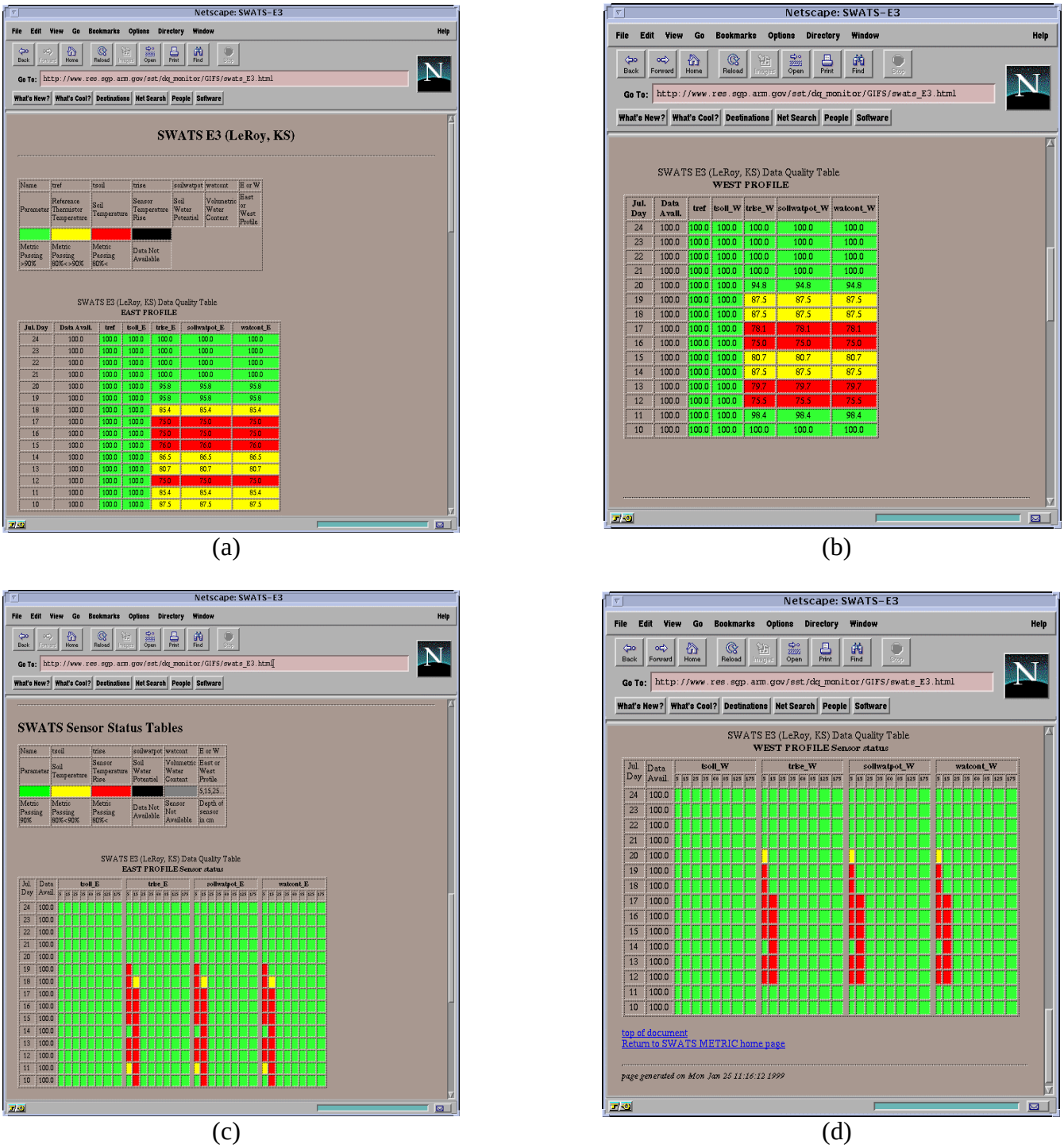


Figure 1. Snapshot of web pages illustrating the data quality module available for SWATS data quality monitoring. These color-coded tables aid in troubleshooting the SWATS platform as a whole (a and b) and each sensor (c and d) in the East and West profiles.

Figure 2 once again represents the passing percentages generated by the performance metrics for each of the SWATS variables in both the East and West profiles. These plots show considerable fluctuation in data availability. The black cells indicate days that no data was available for data quality calculations. In addition, the days that illustrate poor data quality are not necessarily failing the performance metric tests, but rather the amount of data available for these days is considerably low (<60%). This leads to only the percentage of data available passing the performance metric tests.

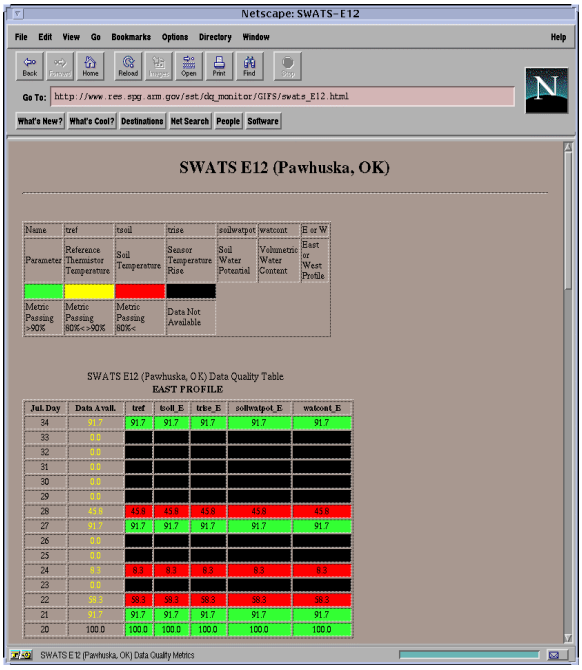
The images in Figure 2 (c and d) once again represent the passing percentages generated by the performance metrics for each of the SWATS variables at each sensor depth in both the East and West profiles. As mentioned above, data availability is the major problem at Pawhuska, Oklahoma, during this time. As illustrated by the sensor images, each sensor has good data quality but the availability is poor. In addition, this sensor plot illustrates how the sensor tables handle the lack of a complete complement of all eight sensors in the profile. During installation of the Pawhuska, Oklahoma site, bedrock was reached before the 85-cm, 125-cm, and 175-cm sensors could be installed. The cells for these depths are issued a color of gray because of the lack of sensors at these depths.

Improvements in SWATS Data Quality

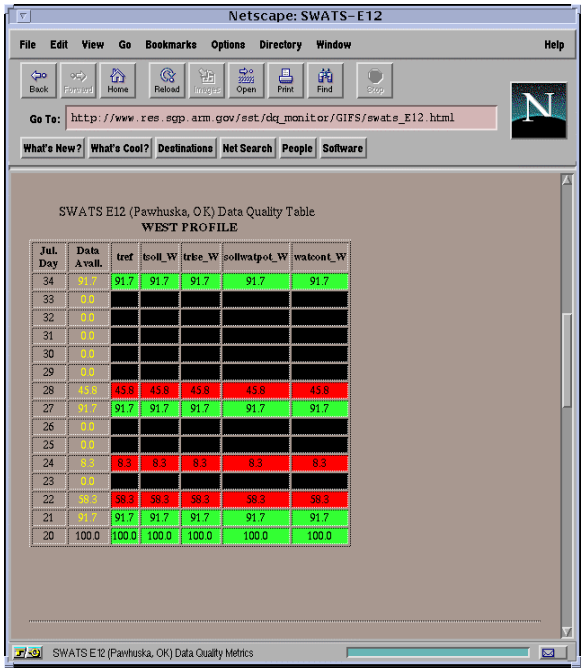
SGP SST personnel view these data quality graphical displays in order to determine the near real-time data quality. Each morning at 1130 Greenwich Mean Time (GMT), the performance metrics are run to determine the data quality at each SWATS site. Next, the data quality graphical displays are produced by automated generation of the web-based color-coded tables (Figures 1 and 2) based on the output of the performance metrics. These displays are then transferred to the Site Scientists SGP CART Site Data Quality Assessment Displays web site located at *www.res.sgp.arm.gov/sst/dq_monitor/DISPLAYS.html*. Each week these plots are viewed in order to issue a Data Quality Report (DQR) to be reported on the ARM SGP SST conference call. In addition, these DQR's act as the information used to issue work orders. These work orders are used by ARM SGP Site Operations as the instructions to address and repair the root cause of the problems being noted. Since the inception of the SWATS performance metrics in February 1998, many sites have been identified as problematic and have been brought back to full working order. In February 1998, 11 of 21 SWATS sites had poor data quality. As of March 5, 1999, only 3 of 21 facilities have problems and two of those are being addressed by a Baseline Change Request (BCR). This BCR addresses the Byron, Oklahoma, and Morris, Oklahoma, facilities and includes moving the data logger enclosure off the ground and mounting it upright several feet off the ground. This is being completed to prevent the leakage of standing water into the enclosure and compromising the electronics. It is anticipated that these two facilities will be fully operational in April 1999.

Continued Monitoring of SWATS Data Quality

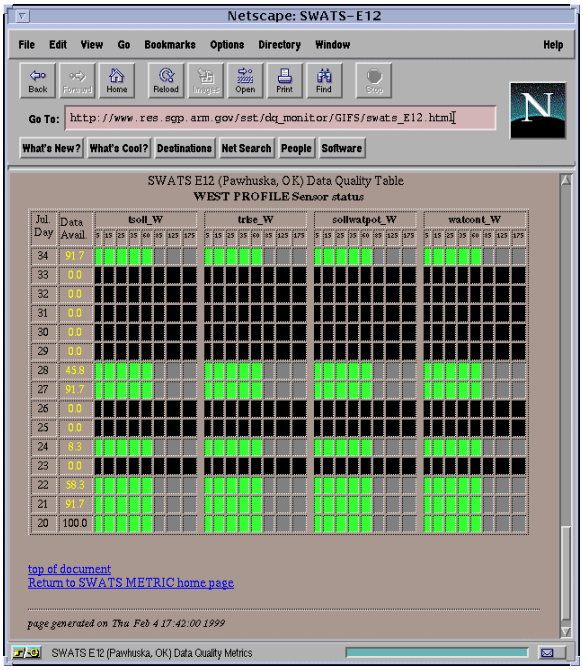
The monitoring of SWATS data quality will continue as part of daily procedures for the SGP SST. Continued cooperation with the mentor will provide the necessary knowledge to fix problems more accurately and timely as they occur. The addition of new quick plots of the data dynamically linked



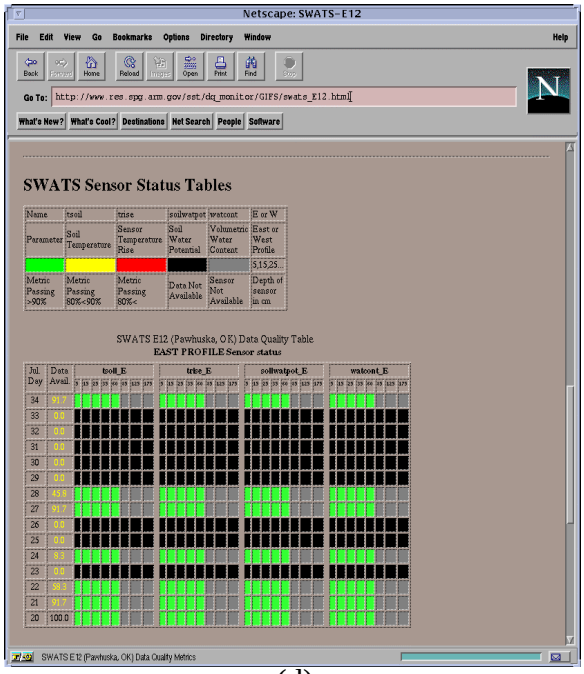
(a)



(b)



(c)



(d)

Figure 2. Snapshot of web pages illustrating data quality module available for SWATS data quality monitoring. Note in these images the poor data availability and the lack of the full suite of sensors in the profile (c and d).

from the color coded cells of the data quality graphical displays will allow a further monitoring of data quality. These quick plots will allow tracking of data quality issues that may be associated with changes in ambient conditions (i.e., excessive precipitation, heat, etc.) Further, the addition of long-term metric monitoring will provide the statistics to track the health and status of the SWATS instruments over a long period of time. This will include the use of the data from the performance metrics in calculations of monthly, quarterly, and yearly statistics to monitor any degradation or improvement in the entire system. These activities should take place during calendar year 1999.