Examples of Detecting Measurement Errors with the QCRad Value Added Product

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Introduction

The QCRad Value Added Product (VAP) is being developed to assess data quality for the surface radiation data collected at the Extended and Atmospheric Radiation and Cloud Station facilities, and to enhance data continuity for missing or "bad" Solar Infrared/Skyrad data. In this study, we processed one year of radiation data, chosen at random, for each of the twenty SGP Extended Facilities to aid in determining the user configurable limits for the Southern Great Plains (SGP) sites. By examining yearly summary plots of the radiation data and the various test limits, we show that the QCRad VAP is effective in identifying and detecting many different types of measurement errors. Examples of the analysis results are presented here.

The QCRad VAP uses two sets of user configurable limits. The first set is chosen such that all data that fall within these limits lie within the realm of good data. The data that fall between the first and second limits are possible, but occur only rarely, thus also may be questionable. Users can explore more to figure out if they will include these latter data in their research. All the data that fall outside the second limit are set as "bad."

Examples of Problematic Data

Problematic data are captured using the criteria we set. By examining the yearly summary plots of each quality control (QC) test, we can easily identify examples of data measurement errors. Below are some examples.

a. "Tracker off" Data Captured

Figure 1 shows the results of the diffuse shortwave (SW) limits test for four SGP Extended Facilities in year 1999 or 2000. The red curve is the baseline surface radiation network defined physically possible limit; the green curve is the first user configurable limit and the blue curve is the second user configurable limit. Times when the solar tracker is not properly aligned with the Sun ("Tracker Off"), the data are caught using the criteria below; and shown in pink in the plots.

"Tracker off" test criteria

Using ClearSW = [**a**/AU^2] x $\mu_0{}^b$, where "a" and "b" are configured by user, μ_0 is the cosine of the solar zenith angle, and AU is the Earth-Sun distance in astronomical units.
Then for Diffuse SW > 50 Wm^{-2},

IF (Sum SW)/ClrSW > 0.85 [or Global SW if Sum SW missing or "bad"]
AND if Dif/(Sum SW) > 0.85 [or Global SW if Sum SW missing or "bad"]
THEN the tracker is not properly following the sun.

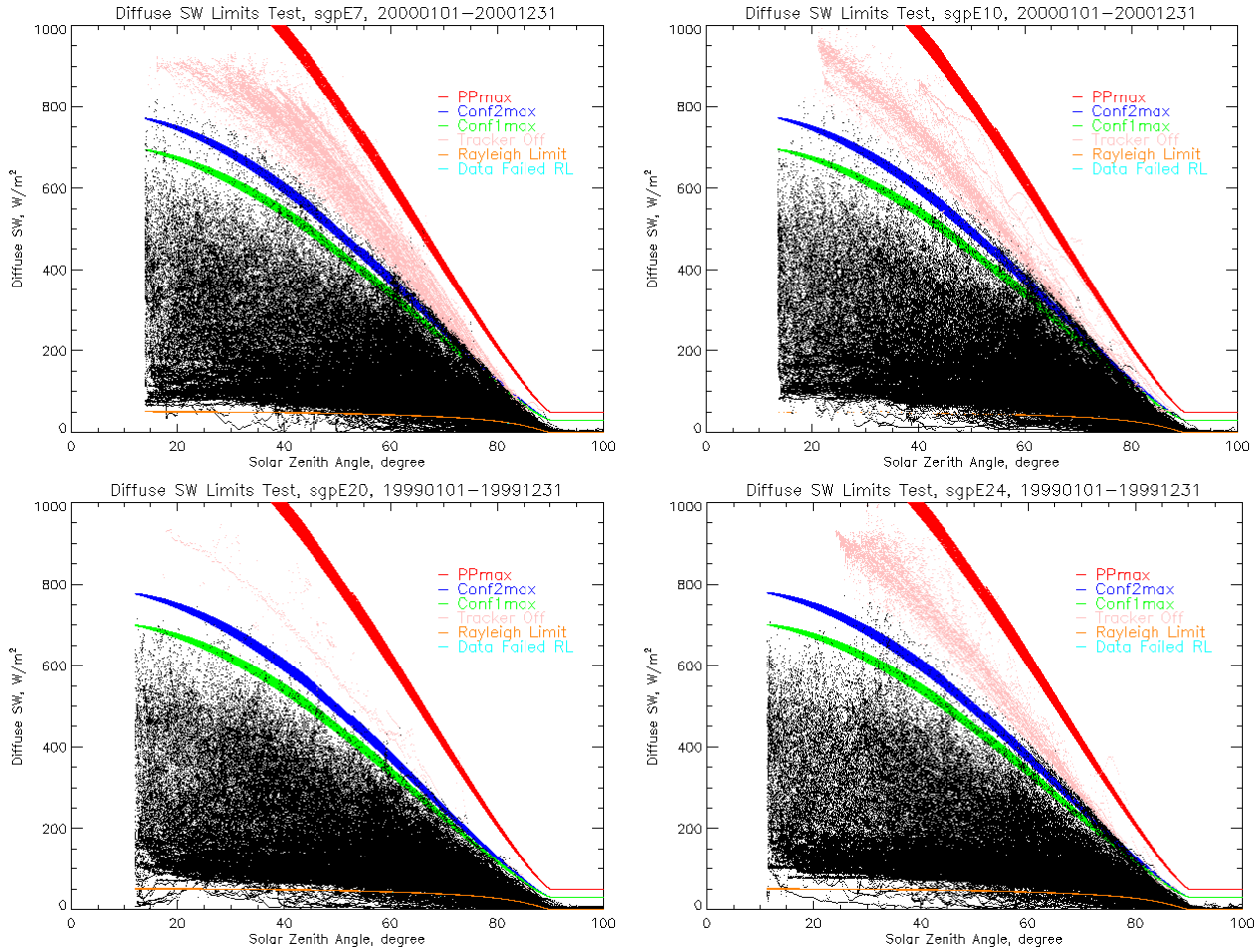

Figure 1. Diffuse SW Limits Test. Top left: sgpE7, 2000; Top right: sgpE10, 2000; bottom left: sgpE20, 1999; Bottom right: sgpE24, 1999.

b. Bad Data Captured at SGP E7

Bad data were captured with the upwelling longwave (LWup) Limits Test and LWup to air temperature (Ta) comparisons for SGP E7 2000 data, as shown in Figure 2. Top left: LWup vs. Solar Zenith Angle. The baseline surface radiation network defined physically possible limits and the two sets of user configurable limits are shown as horizontal colored lines in the plot. Top right: LWup vs. air temperature. The two sets of user configurable limits are shown as colored curves. Both plots show data falling well beyond the reasonable limits. Examination of the data reveal that beginning around 0100 Universal Time Coordinates on June 14, 2000, the LWup case and dome temperatures are primarily missing, or when not missing are either high positive (a typical value is 588.2), or low negative, as shown on the bottom left plot. The same is true for the LWdn case and dome temperatures, as shown on the bottom right plot.

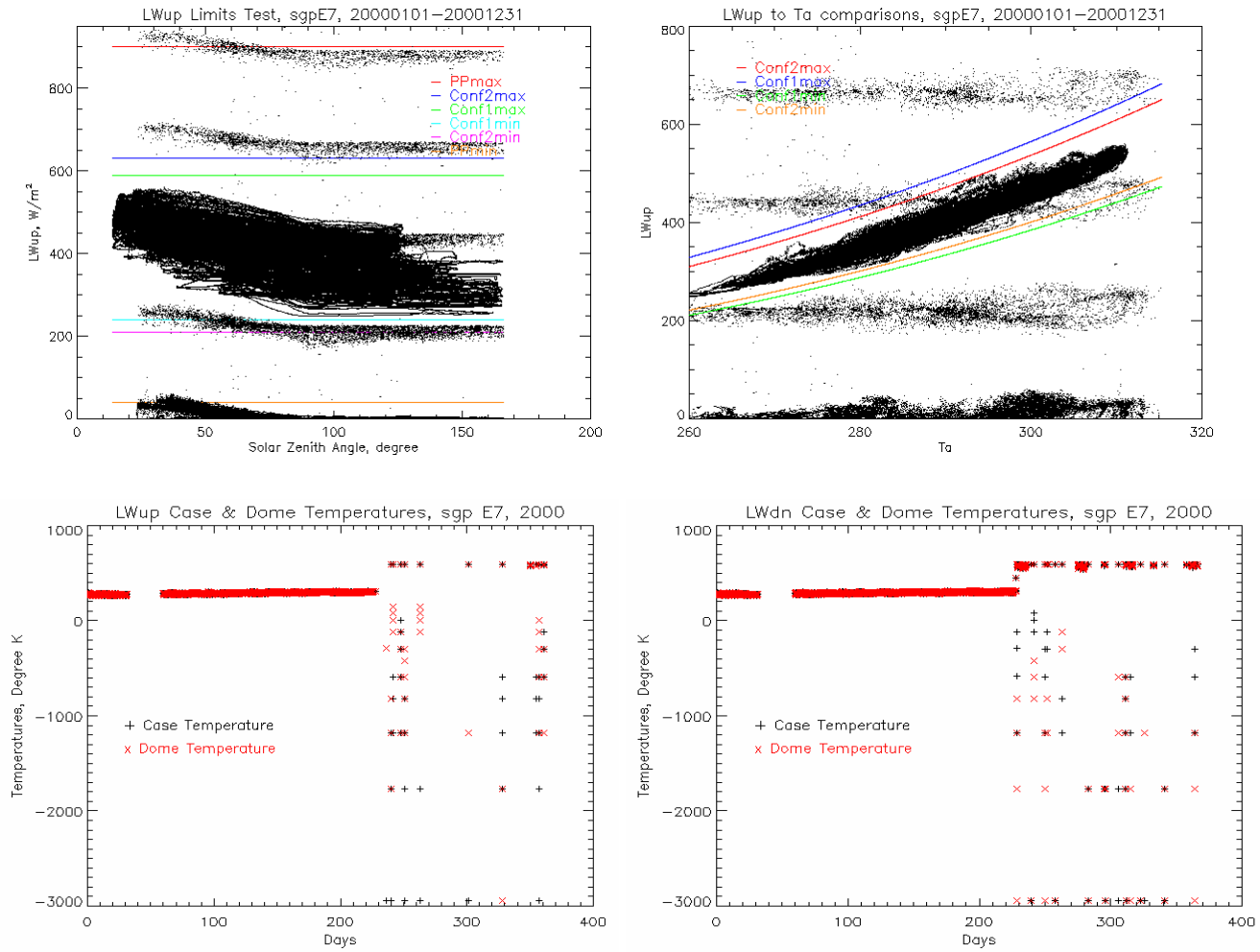

Figure 2. LWup and LWdn tests for sgp E7 2000 data. Top left: LWup vs. Solar Zenith Angle; Top right: LWup vs. air temperature; Bottom left: time series of LWup case and dome temperatures for year 2000; Bottom left: time series of LWdn case and dome temperatures for year 2000.

c. Case and Dome Temperature Offset Problem Caught at SGP E18

An apparent bias in the case and/or dome temperatures of the LW instruments is caught at SGP E18, as shown in Figure 3. Top left is the LWup case and dome temperatures verses air temperature, which shows a case temperature offset in some of the data. Similarly, both a LWdn case and dome temperature offset is shown in the top right figure. The middle left plot shows a time series of LWup case & dome temperatures and air temperature with a case temperature offset before July 10, 2002, while the dome temperature agrees well with air temperature. In the LWdn case however, both the case and dome temperatures have offsets before that date, as shown in the middle right figure. To further assess the problem, we processed 2001 data from this facility, as shown in the bottom plots. These plots show that for the first two and a half months the case and dome temperatures for both upwelling and downwelling LW are missing. For the LWup, the case temperatures are offset throughout the rest of the year while dome temperatures agree well with air temperature. For LWdn, both case and dome temperatures are offset for the rest of the year.

d. Upwelling LW Dome Temperature Error at SGP E3

An upwelling LW dome temperature error is captured by three separate QC tests, as shown below for SGP E3 2000 data. The top left plot is the LWup Limits test. User configurable limits and physically possible limits are shown as colored horizontal lines. This plot shows some LWup data scattered beyond the limits; Top right plot shows LWup case & dome temperatures vs. air temperature, with upper and lower limits shown as red and green lines respectively. We can see a batch of blue dots on the top of the plot, which means LWup dome temperatures are off limits. The bottom left plot shows LWup vs. air temperature, which also shows scattered data off limits. The time series plot on the bottom right shows that beginning around day 160, the dome temperatures start to behave erratically. These offset problems are also caught in other QC tests. Following this research, a Data Quality Report will be filed to note this data problem.

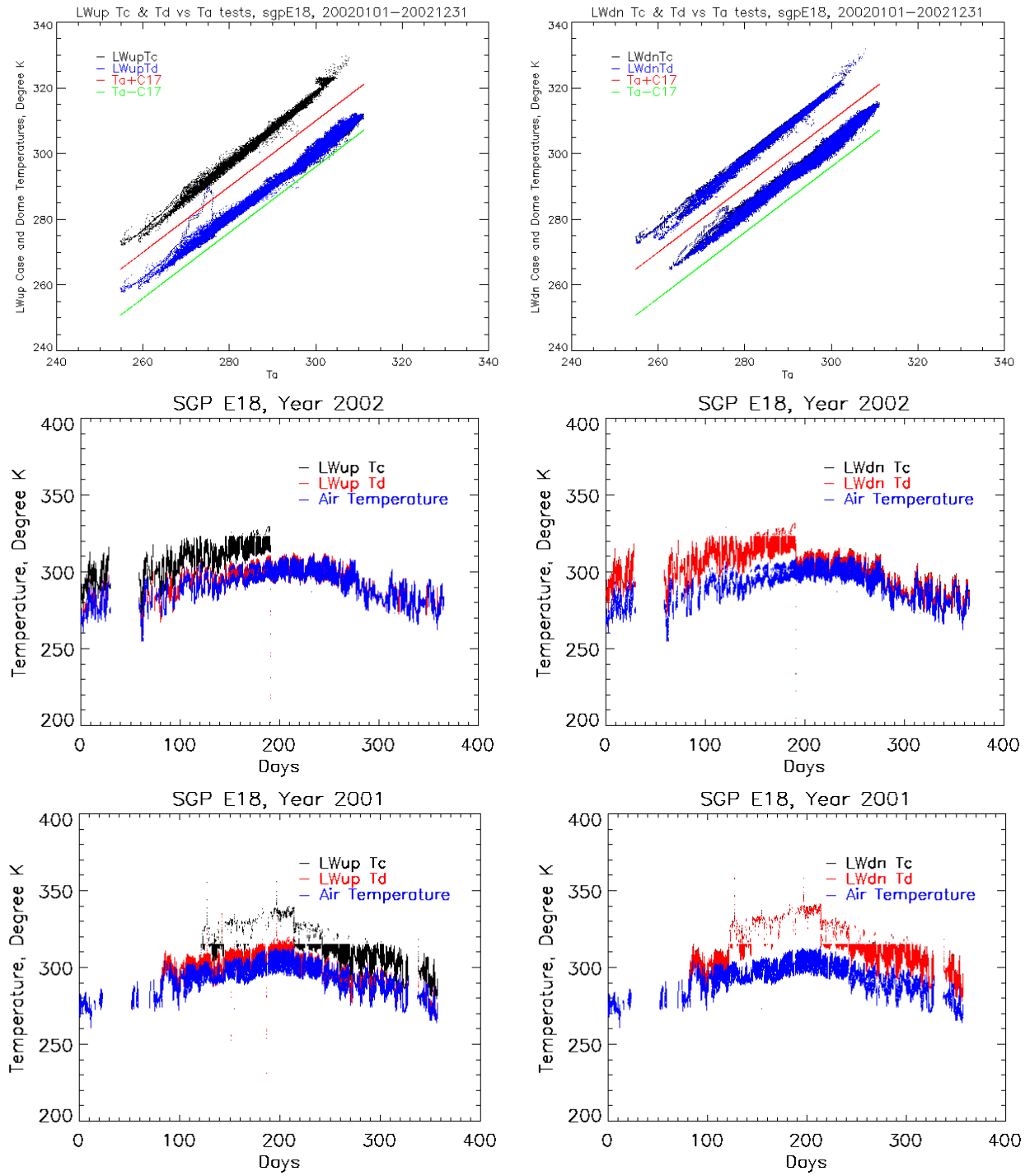

Figure 3. Case and dome temperature offset at SGP E18. Top left: LWup case & dome temperatures vs. air temperature; Top right: LWdn case and dome temperatures vs. air temperature; Middle left: time series of LWup case & dome temperatures in 2002; Middle right: time series of LWdn case & dome temperatures in 2002; Bottom left: time series of LWup case & dome temperatures in 2001; Bottom right: time series of LWdn case & dome temperatures in 2001.

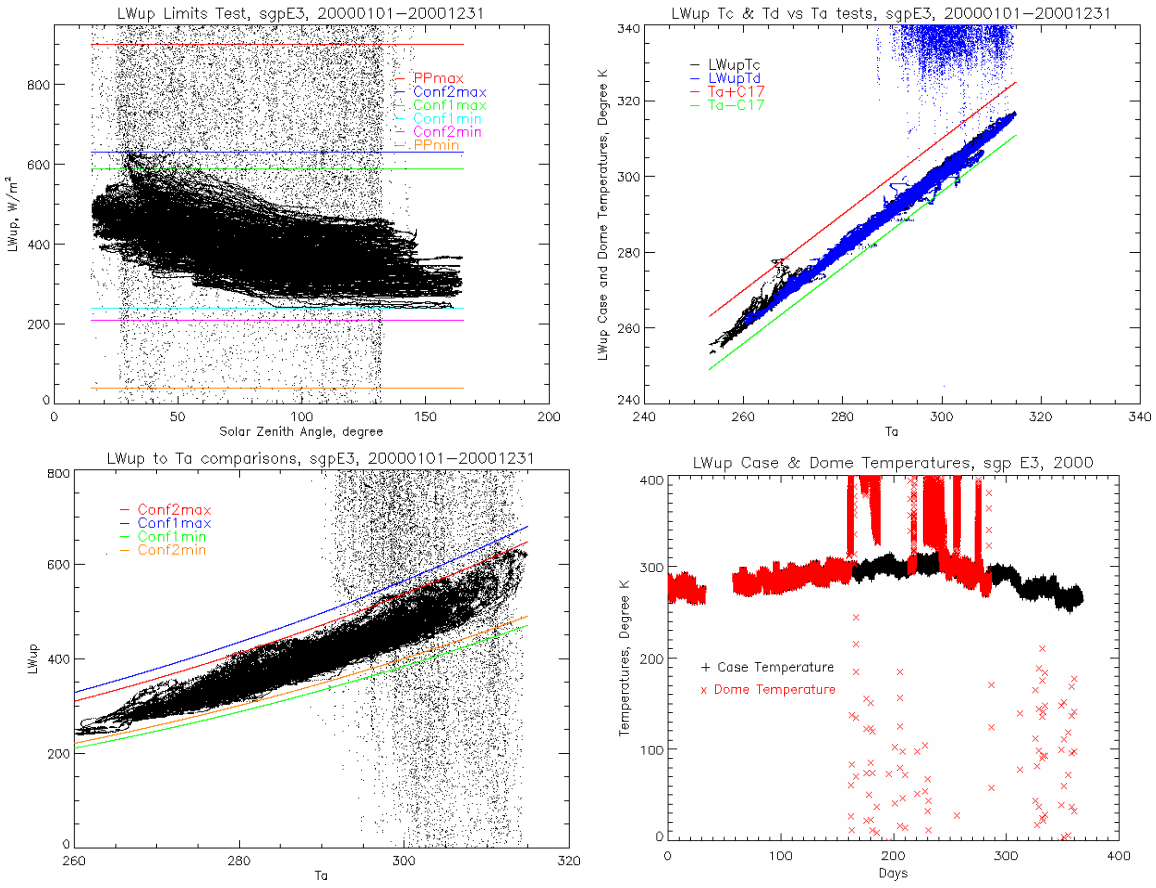

Figure 4. LWup tests for sgp E3 2000 data. Top left: LWup vs. Solar Zenith Angle; Top right: LWup case & dome temperatures vs. air temperature; Bottom left: LWup vs. air temperature; Bottom right: time series of LWup case and dome temperatures.

e. SWup Albedo Test

The upwelling SW (SWup) albedo test on 2002 SGP E12 data shows some data exceeding reasonable limits, as shown on the left plot of Figure 5. The right plot on Figure 5 shows the yearly time series of the total downwelling SW in black and upwelling SW in red, illustrating that from February to June 2002 the upwelling SW measurements are mostly missing, with some obviously erroneous data reaching values as high as 1500 Wm^{-2}.

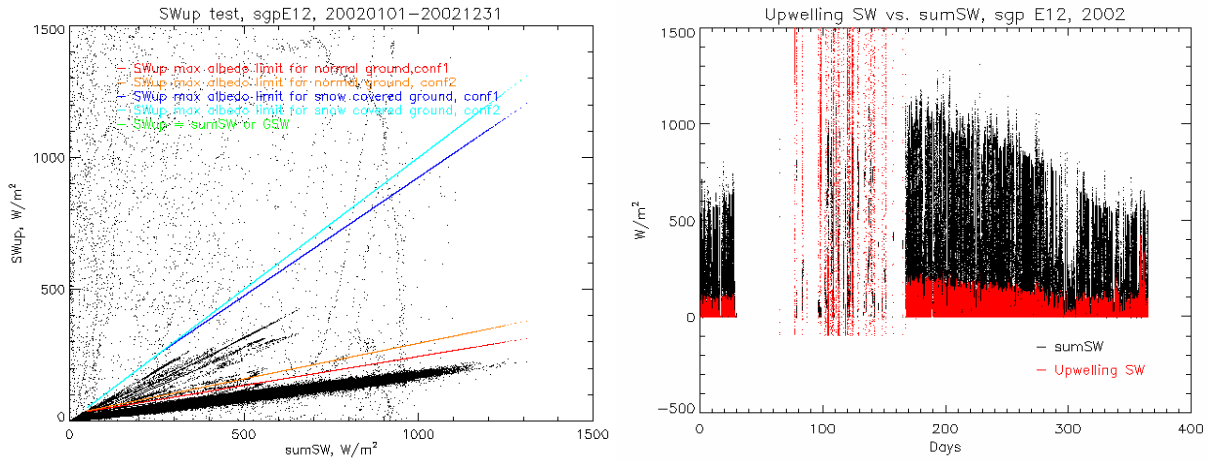

Figure 5. SWup tests for sgp E12 2002 data. Left: SWup tests with two sets of limits for normal ground (red and orange curves) and snow covered ground (blue and cyan curves); Right: time series of upwelling SW.