Results of the Dutton et al. IR Loss Correction VAP: Statistical Analysis of Corrected and Uncorrected SW Measurements

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Introduction

Last year at the Science Team Meeting we presented an extended abstract: *Analysis of the Dutton et al. Infrared (IR) Loss Correction Technique Applied to Atmospheric Radiation Measurement (ARM) Diffuse Shortwave (SW) Measurements*. Based on this work, we have developed an ARM value-added product (VAP) called the SW DIFF CORR 1DUTT VAP that applies the correction technique to diffuse SW measurements across the Southern Great Plains (SGP) site. Here we present an analysis of results on the magnitude and frequency of these corrections for selected facilities at the SGP site.

Analysis of Seasonal versus Yearly Fits

For this analysis we used two facilities at the SGP site that had a 3-year span of data from the same pair of radiometers. Because the Eppley Precision Spectral Pyranometer (PSP) was neither switched nor calibrated during this time period, the question was whether to use seasonal or yearly fits to correct the diffuse SW measurements. We calculated the average case temperature, dome temperature, detector flux, and average case dome temperature difference for the summer and winter seasons of each year. We also calculated correction coefficients for summer and winter of each year, for each whole year, and for the whole 3-year span. Finally, we calculated Detector and Full corrections using correction coefficients for each time period with the averaged seasonal values.

In Figure 1 for the SGP E9 facility the biggest difference was between the 3-year Full correction compared to the Seasonal Full correction value for the summer Y1 (SM Y1). This represents about 3.5 Wm^{-2}. In all other cases the difference between seasonal, yearly, and 3-year Detector and Full correction represents about 1-2 Wm^{-2}. In Figure 1 for the SGP E20 facility the biggest difference was between the winter Y3 (WT Y3) Full correction and the yearly Full correction value. This represents about 4.5 Wm^{-2}. In all other cases the difference between seasonal, yearly, and 3-year Detector and Full correction represents about 1-2 Wm^{-2}.

The conclusion is that there is little significant difference between seasonal and yearly correction fitting. The differences shown are not significant compared to the uncertainty of the methodology and the magnitude of the calculated IR loss for the corrected data. (For correction frequency distributions, see

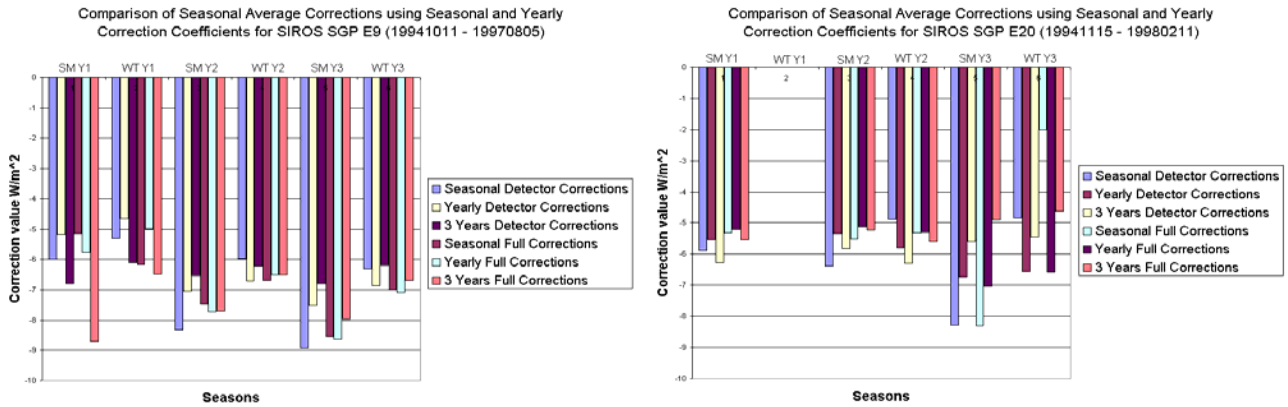

Figure 1. Comparison of seasonal average corrections for solar and infrared observing system data SGP E9 and SGP E20.

extended abstract from last year: *Analysis of the Dutton et al. IR Loss Correction Technique Applied to ARM Diffuse SW Measurements*.) It is possible some of the noted differences could be attributed to the calibration drift over the 3 years.

Analysis of the Average Detector and Full Corrections for Seasons and Years

For the analysis in Figure 2 we used corrected SW measurements from the SGP site from January 1, 1998 to December 31, 2000. We used data from 5 facilities representing each quadrant (North West [NW], North East [NE], South West [SW], South East [SE] and Central Facility [C]). We then calculated the average Detector and Full correction for all four seasons and for each year.

In general the least Detector and Full correction is applied in winter, while the most correction is applied in spring, summer, and fall. This is consistent across all compared facilities. Also in general there is less correction in the year 2000 than 1998 or 1999 except for the SE facility (E18). The differences in average correction magnitude are not large across SGP site and exhibit about the same amount of variability.

Correction Frequency Distribution

For the analysis in Figure 3 we used the same data as in the Figure 2. We compare the frequency distributions of the Detector only correction value and Full correction value applied to the diffuse SW measurement. There is a tendency for the Detector only correction to have a bi-modal distribution typically in the spring and less often in the fall and winter seasons. There appears a bi-modal distribution in 1998 but not in other years for all sites. The Central Facility is an exception to this observation where there is a slight tendency for bi-modal distribution in all 3 years (1998, 1999, 2000).

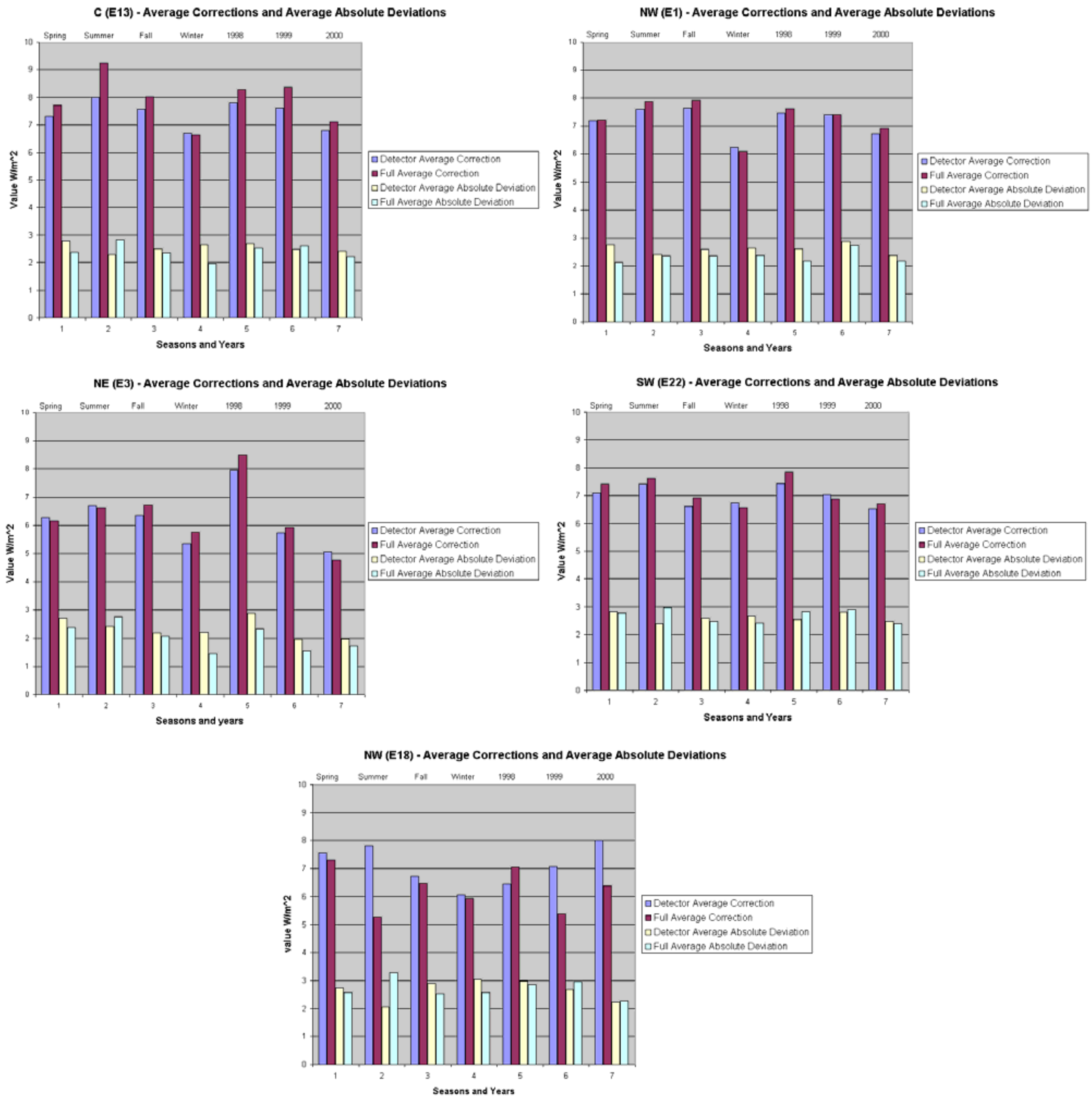

Figure 2. Average corrections and average absolute deviations for SGP SW, SE, NW, NE, and C.

We showed last year that a bi-modal behavior in the nighttime offset data was associated with moist, heavy overcast conditions. (See extended abstract from last year: *Analysis of the Dutton et al. IR Loss Correction Technique Applied to ARM Diffuse SW Measurements*.) We also can note that during 1998 there was a strong El Niño event. This could have some relation to these results, but more analysis needs to be applied to study any possible relationship.

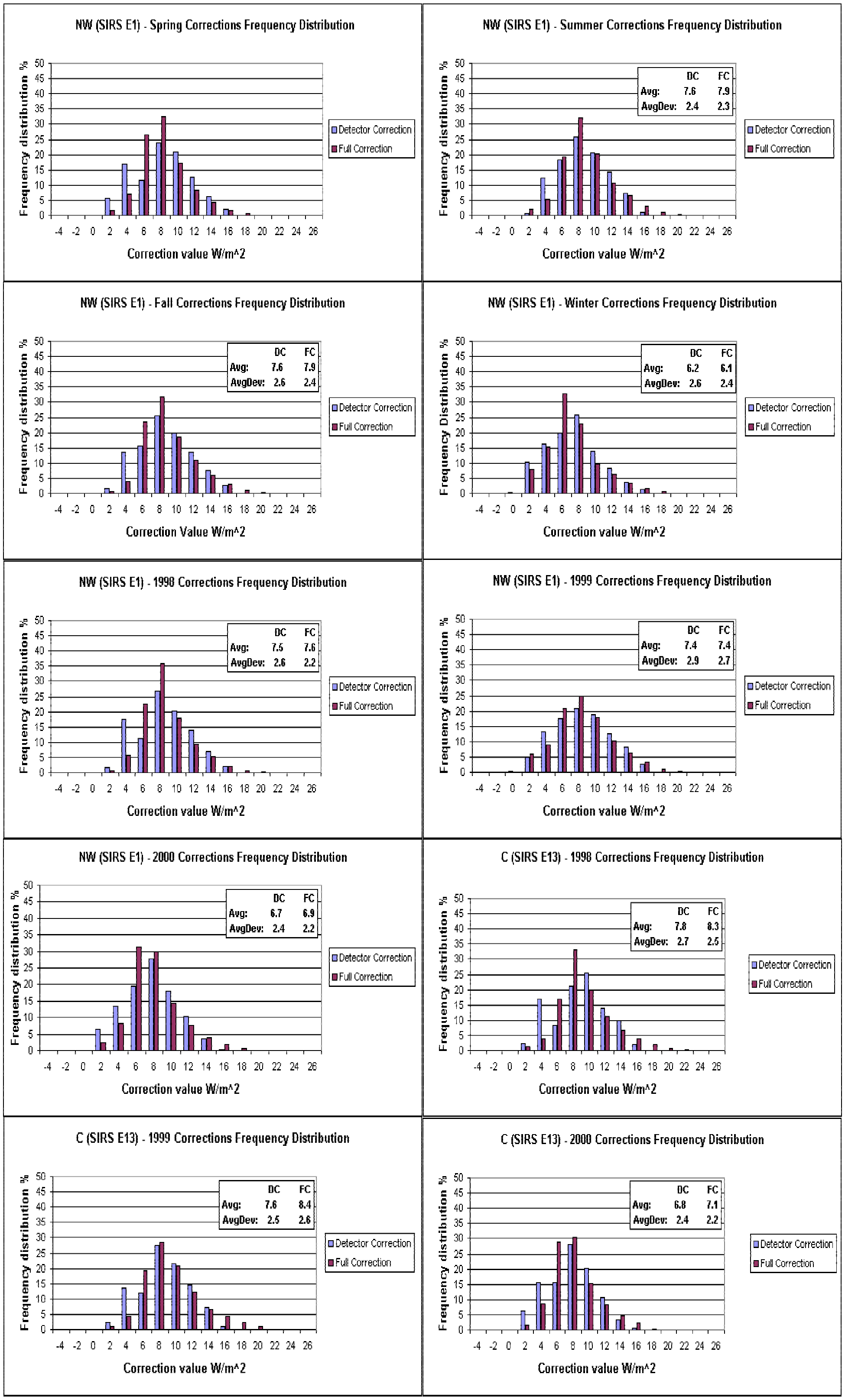

Figure 3. Correction frequency distribution for seasons and years for SGP NW and SGP C.

Average Detector and Full Corrections and Extreme Corrections for Summer and Winter Seasons

For this analysis we used corrected SW measurements from the SGP site from January 1, to December 31, 2000. We used data from 5 facilities representing each quadrant (NW, NE, SW, SE and C). We calculate the average case temperature, dome temperature, detector flux, detector flux standard deviation and average case-dome temperature difference for the summer and winter seasons. We apply the Detector and Full correction coefficients calculated for each yearly time period to the averaged values. The average Detector and Full correction value is calculated with the average Detector Flux and Case-Dome Temperatures. The extreme correction values are calculated as the average input values plus two times the standard deviation.

In the Figure 4, generally the average Detector and Full corrections are about the same. The biggest difference is for the summer (SM) Central Facility at about 2 Wm^{-2}. In the other instances the difference is generally less than 1 Wm^{-2}. The difference for the average extreme Detector and Full correction is much higher, as expected. The biggest difference is for the winter (WT) Central Facility. It represents about 6 Wm^{-2}. The winter corrections again appear to be generally lower than summer corrections.

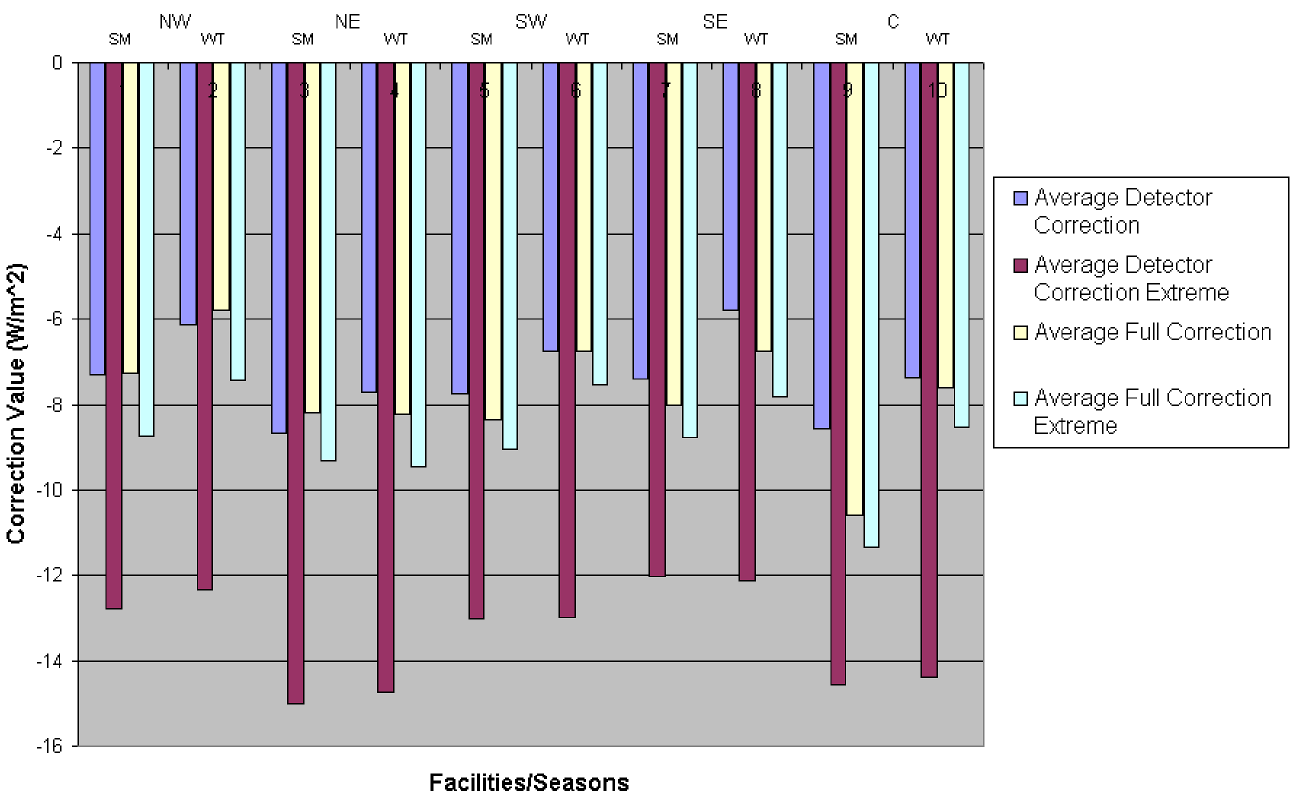

Figure 4. Average detector and full corrections and extreme corrections for summer and winter seasons.

From the averaged Full Correction we separated the Detector part of the correction and the Case-Dome Temperature difference part of the correction (Figure 5). We can clearly see that the Case-Dome Temperature part of the averaged Full correction has a much bigger influence on the correction. This at first might seem surprising, because the average detector-only correction is about the same magnitude as the average Full correction. The plots in Figure 6 help show why this is so, and help explain why we recommend that the Full correction output be used as the data of choice from the ARM DiffCorr1Dutt VAP.

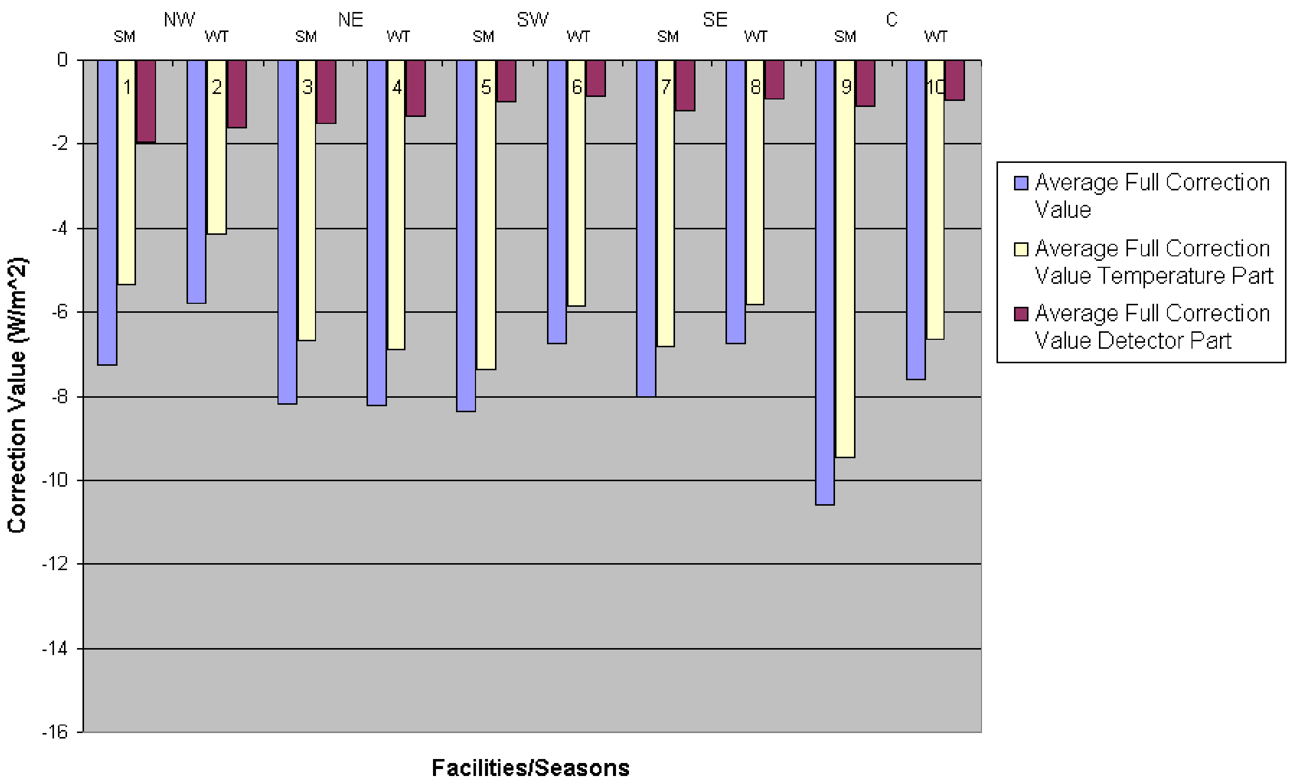

Figure 5. Partitioned full corrections for summer and winter seasons.

Comparison of Detector-Only and Case-Dome Temperature Corrections

As noted in Figure 5, the amount of diffuse SW correction by the Case-Dome temperature term in the Full correction technique is by far the larger compared to the detector portion. The top left plot of the Figure 6 shows an example comparison of 15-minute averages of nighttime PSP offset versus the corresponding detector flux term of the co-located Precision Infrared Radiometer (PIR). The fitted line (green) that represents the correction coefficient is forced through zero. The reasoning for this is that if there is no net IR loss, there should be no correction. However, the basic design differences between the pyranometer and pyrgeometer rarely give what appears to be a trend toward the (0,0) point in these co-located data. It is considered most important to apply a more accurate correction when large corrections are needed (typically clear-sky cases), because the correction magnitudes are small when there is small PIR detector loss and thus the correction errors at this part of the scale are also small.

The top right plot of Figure 6 shows the same relationship as in the top left plot, but for the Case-Dome Temperature term. The Case-Dome Temperature term is calculated in units of Wm^{-2} using the Stephan-Boltzman relation. As the plot shows, the Case-Dome Temperature term does exhibit more of a tendency to trend toward the (0,0) intersection, and appears to be generally a "better behaved" relationship with the PSP nighttime offset. As with the detector flux term, we again fit a line forced through zero to determine a correction coefficient for the Case-Dome Temperature term alone (red line).

Applying the Case-Dome Temperature coefficient derived from the linear fit, we can then look at the residual differences between the correction term and the nighttime measurements, shown in the bottom left plot of Figure 6. As is shown, a linear fit through these residuals (red line) results in a very small additional correction factor based on the PIR detector flux term (X axis). In addition, the residuals themselves exhibit considerable scatter to the detector flux due to the basic design differences between the instruments.

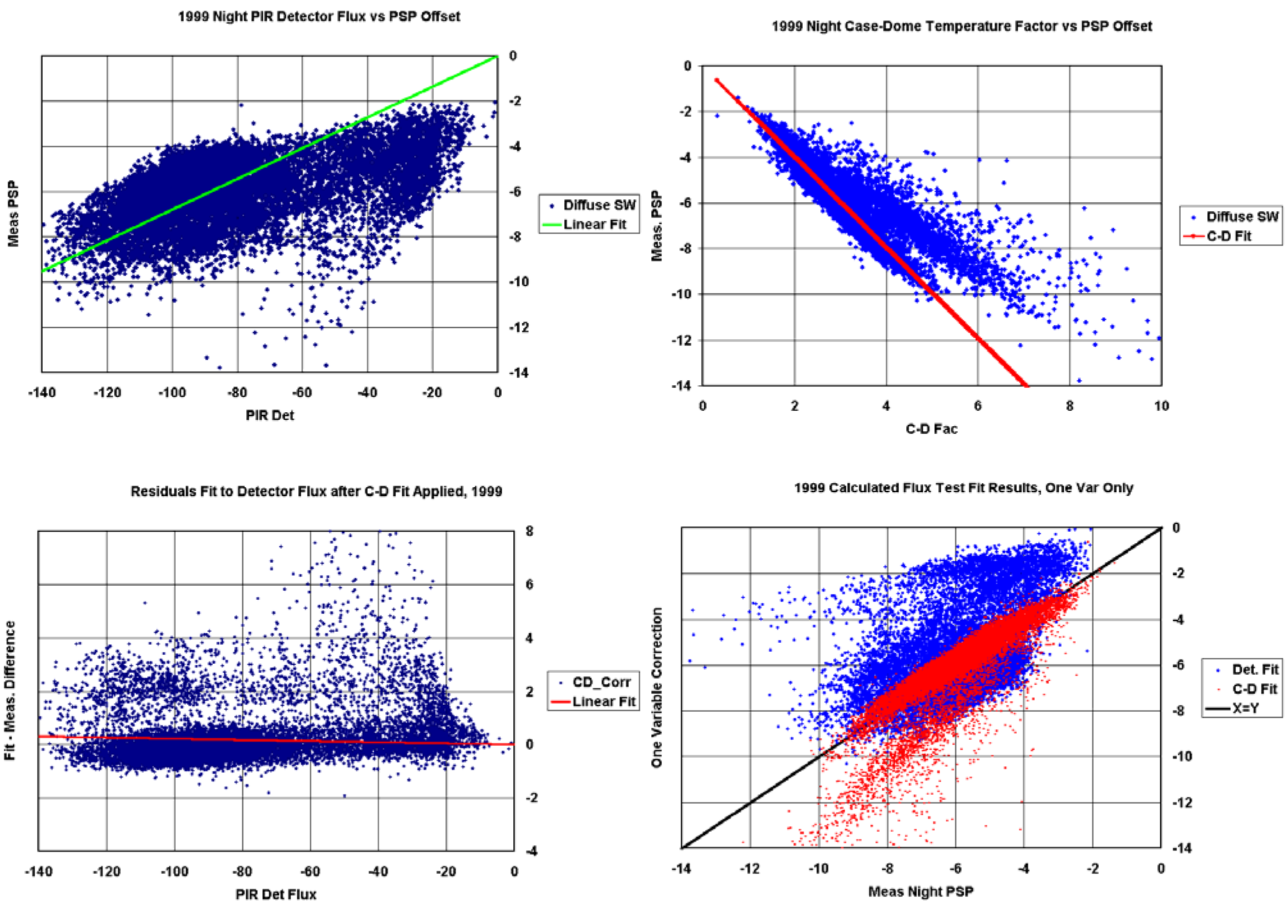

Figure 6. Comparison of detector-only and case-dome temperature corrections.

The plot on the bottom right of Figure 6 shows a comparison of the correction term calculated using the fit coefficients derived in the top two plots for the detector flux and Case-Dome Temperature correction techniques. While both corrections exhibit some times when the correction is not well accomplished, the plot shows that most of the time the Case-Dome-based correction exhibits better behavior. For this reason, we recommend use of the Full correction data in the VAP output if available, then use of the detector-only correction data if not.

Conclusions

The DiffCorr1Dutt VAP output is currently available from the ARM Archive. The VAP output includes the measured SW (diffuse, direct, and total), downwelling LW, and both "detector-only" and "full" corrected diffuse SW values. The corresponding meteorological data (air temperature, relative humidity, surface pressure) is included. In addition, we include the PIR detector flux and case and dome temperatures (for users who might want to determine their own IR loss corrections), and a Rayleigh diffuse SW limit calculation.

Our choice of using yearly data for determining the correction coefficients seems to be valid from available data. No perceived advantage is gained using seasonal fitting.

The frequency distributions of the correction amounts exhibit a bi-modal tendency for the detector-only correction, especially in the spring and in the yearly statistics of 1998.

There does not appear to be significantly large differences in average correction amounts or variability in the long-term statistics across the SGP domain. On average, less correction is needed in winter, and more correction the rest of the year.

For the Full correction, most of the correction amount comes from the Case-Dome Temperature term. The relationship between the Case-Dome Temperature term and the PSP nighttime offset is "better behaved" than the PIR detector – PSP relationship. In addition, the Full correction does not exhibit a bi-modal tendency in the frequency distributions. The Full correction involves more factors, thus there is a slightly higher tendency for data quality control to prohibit the Full correction from being possible compared to the detector-only correction. Given this, we recommend that, as a first choice, the Full correction values be used if available, then the detector-only correction values if the Full correction is not available.