Asymmetry in the Diurnal Cycle of Atmospheric Downwelling Radiation at the ARM SGP CF Site Over 1995-2001 Period

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Introduction

The shape of the diurnal cycle of atmospheric downwelling radiation is an important climatic feature of cloud-radiation interactions and atmospheric properties. Adequate characterization of this diurnal cycle is critical for accurate determination of monthly and seasonal radiation budgets from a limited data sampling. This is especially important for establishing the optimal sampling and temporal interpolation schemes employed in satellite radiation budget missions, such as Earth Radiation Budget Experiment (ERBE), Scanner for Radiation Budget (ScaRaB), and Clouds and Earth's Radiant Energy System (CERES) (Standfuss et al. 2001; Rieland and Raschke 1991).

Data

To study the diurnal cycle of atmospheric downwelling radiation at the Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) site, we analyzed the dataset of Baseline Surface Radiation Network (BSRN) measurements available from the ARM data archive with shortwave (SW) flux measurements corrected for the thermal offset error. The data file type was sgpbsrn1duttC1.c1. Data covered the period from May 1995 to January 2001 (~ 6 years, 1996 files). Monthly average downwelling SW and longwave (LW) surface fluxes for each 15-minute time interval of diurnal cycle were computed over the 6-year period. Original BSRN measurements were also analyzed for the global hemispheric downwelling SW irradiance. There are numerous gaps in corrected data that frequently coincide with clear-sky intervals and may possibly introduce biases in statistics of corrected SW fluxes toward cloudy scenes (Figure 1).

Results

The seasonal cycle of fluxes, shape of the diurnal cycle and asymmetry in the distribution of radiation with respect to local solar noon were determined. Figure 2 shows the monthly mean diurnal cycle of SW total transmittance for daytime period (black curve). Cosine of the solar zenith angle (SZA) is also shown in red. Although the distribution of SW transmittance in general follows to cosine of SZA that determines atmospheric air mass, there are some important irregularities. Figure 3 shows the complete diurnal cycle of a monthly mean LW fluxes. Monthly mean daily average values are presented in Figure 4. Maximum daily mean SW fluxes were found for June and July, while maximum daily mean

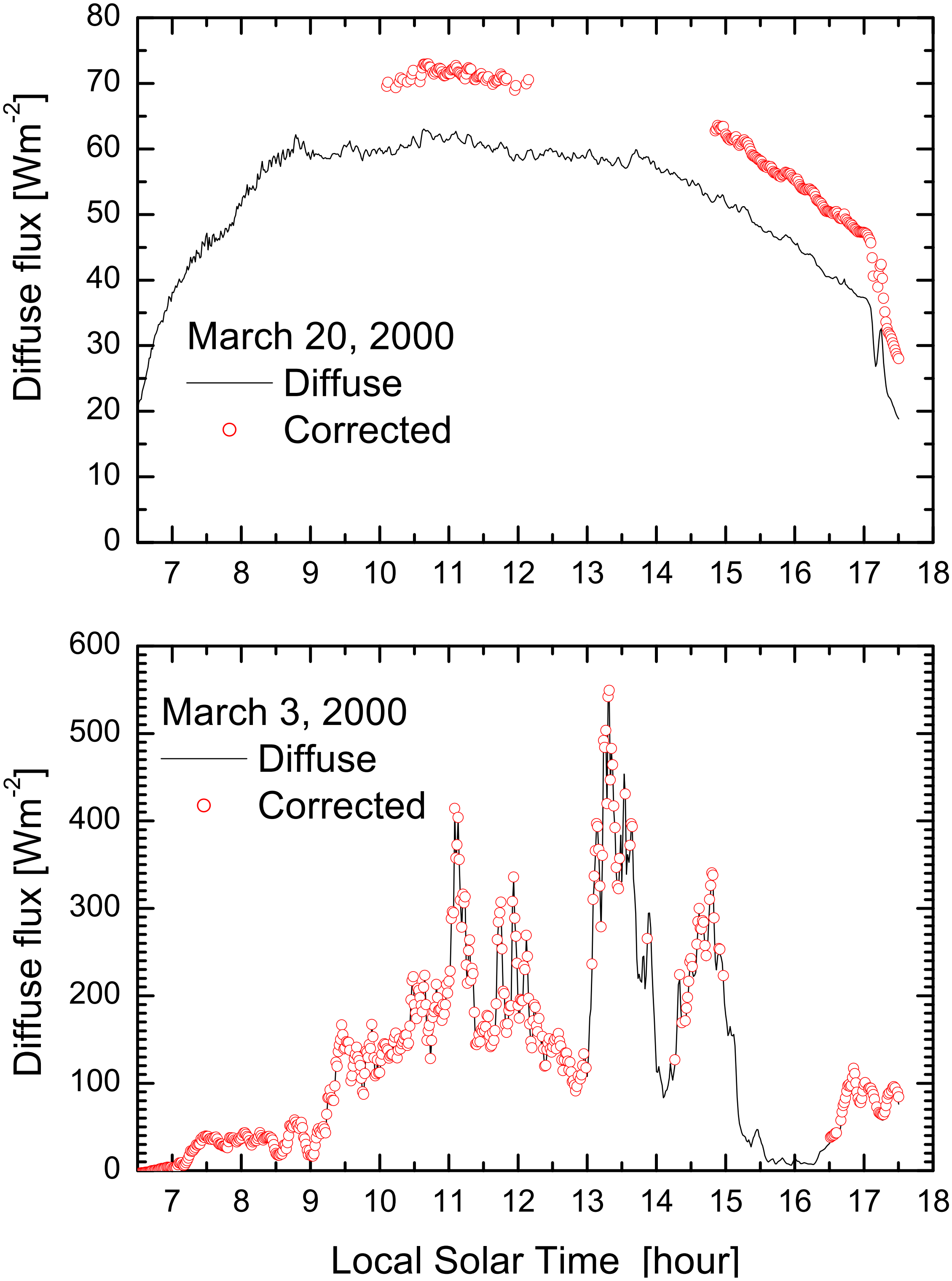

Figure 1. Corrected and uncorrected diffuse solar irradiance. Substantial gaps in data for clear-sky conditions are observed, that may lead to certain biases toward cloudy scenes when computing radiation climate based on corrected data only.

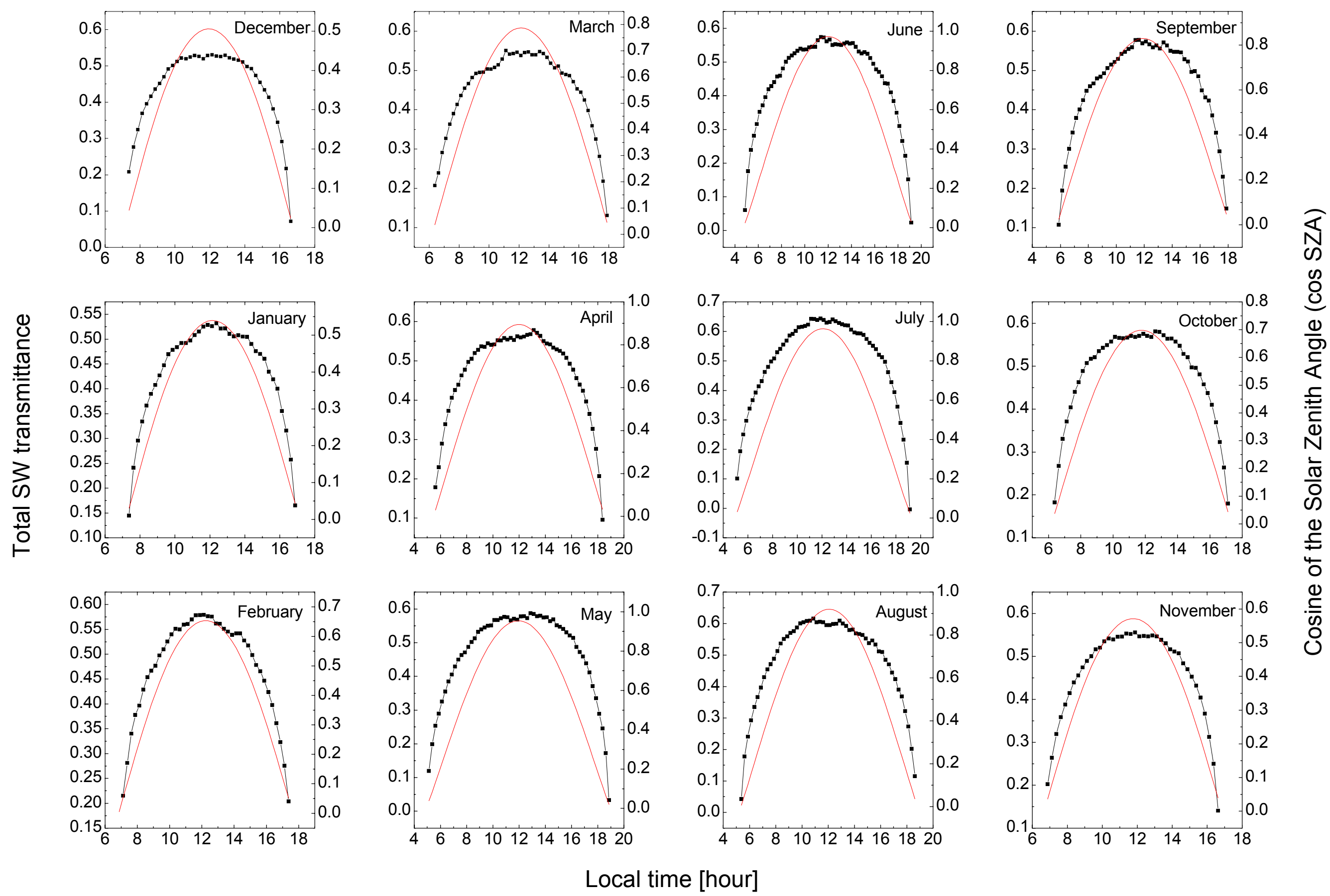

Figure 2. Diurnal cycle of monthly mean SW transmittance. Black line denotes SW transmittance, red line denotes cosine of the SZA.

LW fluxes were in July and August. Figure 5 shows the absolute value of asymmetry defined as the difference between average fluxes for 0-12 h and 12-24 h time intervals and relative value, which is absolute value normalized to daily average value for specific month. The degree of asymmetry in the diurnal cycle of SW radiation shown in Figure 5 varied between -15% in February to + 16% in November. During the warm season from March to October, the SW fluxes are higher in the afternoon hours. As a result, the average annual diurnal cycle of SW radiation was also found biased toward afternoon hours. The LW fluxes demonstrated an important asymmetry in the diurnal cycle with a well-pronounced maximum between 14 and 17 Local Standard Time (LST).

Summary

Seasonal cycle of fluxes, shape of the diurnal cycle and asymmetry in the distribution of SW and LW radiation with respect to local solar noon were determined. Maximum daily mean global SW fluxes were found in July (264 Wm^{-2}), while maximum daily mean diffuse fluxes were in May and June (101.5 Wm^{-2} and 99 Wm^{-2}). The maximum daily mean LW fluxes were in July (403 Wm^{-2}) and August (401 Wm^{-2}).

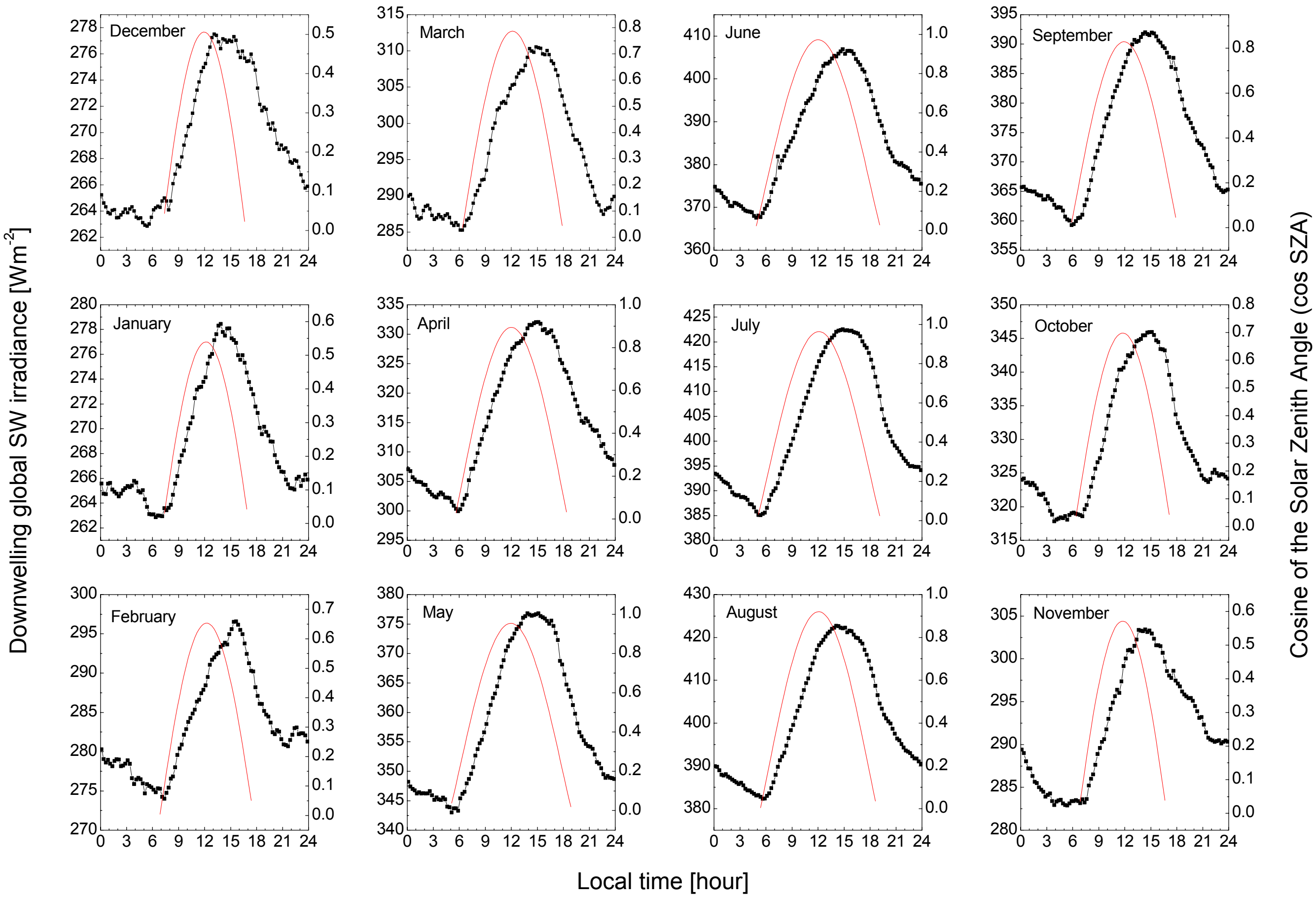

Figure 3. Diurnal cycle of surface LW downward flux. Black line denotes LW flux, red line denotes cosine of the SZA.

The degree of asymmetry in the diurnal cycle of SW radiation varied between -15% in February to +16% in November. From January to August, the SW fluxes are higher in the afternoon hours. As a result, the average annual diurnal cycle of SW radiation was also found biased toward afternoon hours. This trend exists for global and diffuse fluxes.

The LW fluxes display an important asymmetry in the diurnal cycle with a well-pronounced maximum between 14 and 17 LST, although the amplitude of diurnal cycle is much less than for the solar radiation. As a result, the asymmetry in the diurnal cycle of downwelling LW radiation is always negative meaning larger LW fluxes in afternoon hours.

Described features of atmospheric radiation climatology are important (especially for LW component) and have to be taken into account in the determination of daily mean fluxes with reduced data sampling.

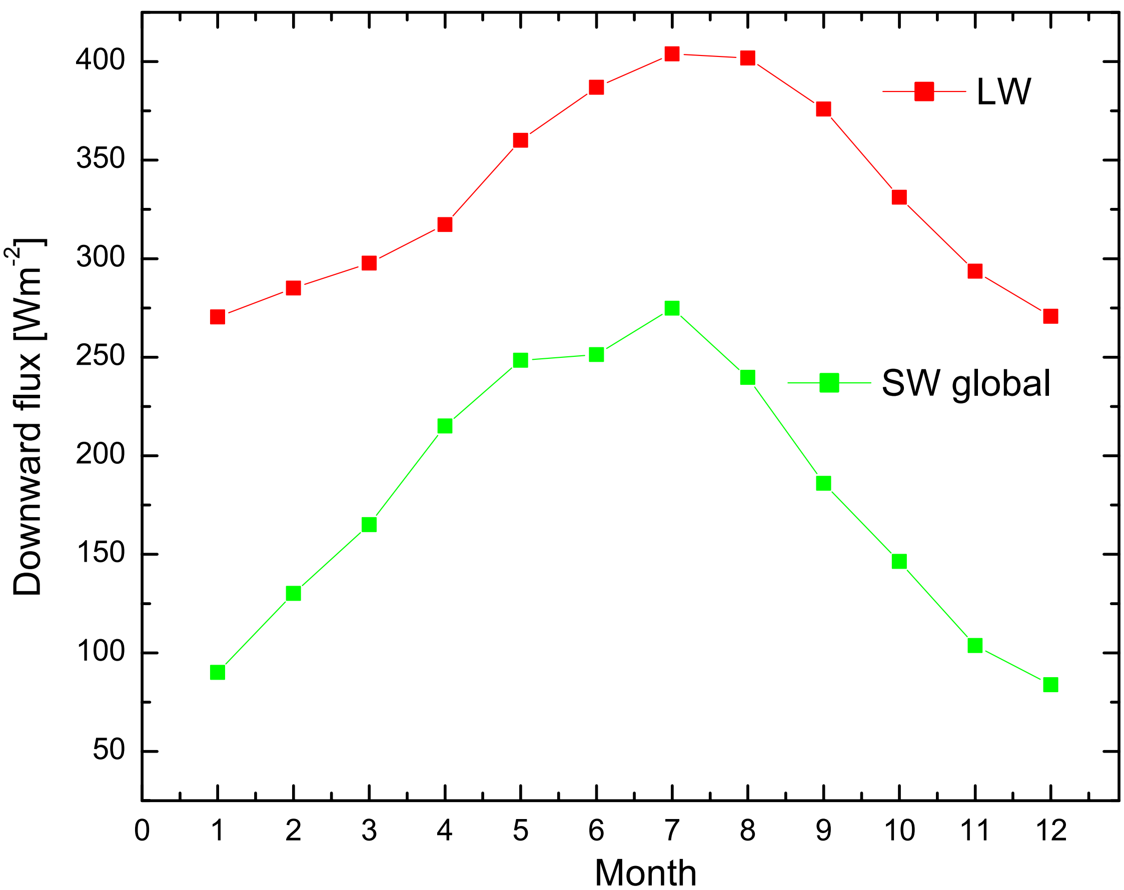

Figure 4. Seasonal cycle of monthly mean of 24-hour average values for SW and LW downward fluxes.

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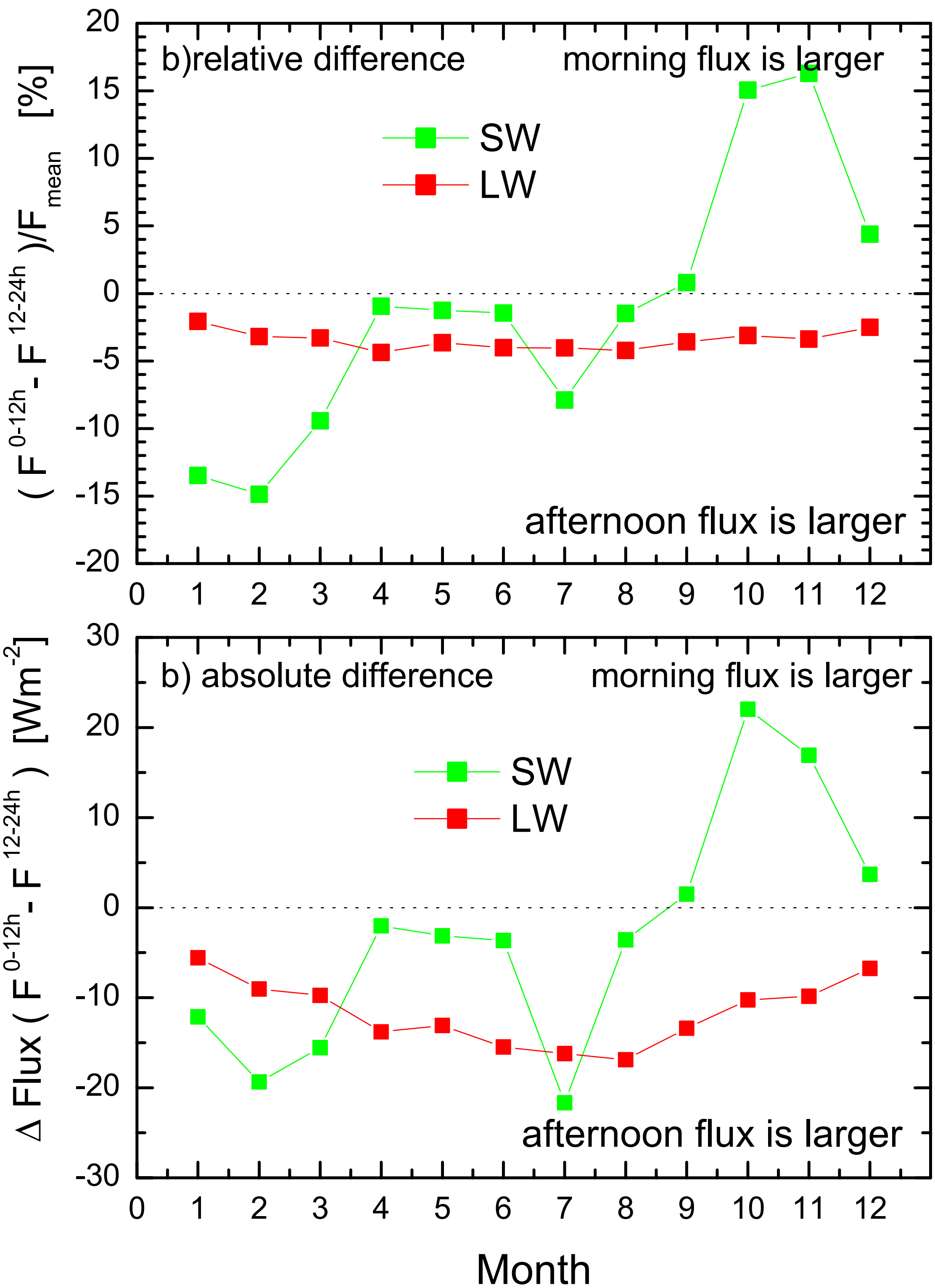

Figure 5. Seasonal cycle of relative (top) and absolute (bottom) asymmetry in diurnal flux distribution over ARM SGP CF site in Oklahoma.

References

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