7.2 COMPARISON OF THE MODELED AND MEASURED DIFFUSE IRRADIANCE FOR SELECTED CLEAR-SKY CASES AT MID-LATITUDE SURFRAD SITES

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1. INTRODUCTION

The ability of radiative transfer models to predict broadband fluxes under clear sky conditions has been the focus of numerous studies over the past few years. Because models generally can simulate accurately the direct normal component, the emphasis is on how well the models can predict diffuse irradiance. Previous studies have found that at a high altitude site and at sea level Arctic sites the modeled diffuse irradiance is in good agreement with the measured values (Kato et al., 1991; Barnard and Powell, 2002). Similar studies performed at the mid-latitude ARM Southern Great Plains (SGP) site in Oklahoma, however, find that the model calculations are consistently higher than the measured diffuse irradiance even when corrections for IR loss have been applied (Halthore and Schwartz, 2000; Powell et al., 2002). This result has led to much speculation as to whether this observed discrepancy might be attributed to the mid-latitude location and the influence of continental air-masses or more specifically to the SGP site itself. To address this question, we carried out comparison studies of modeled and measured clear sky diffuse irradiance for several mid-latitude sites that are part of the Surface Radiation Budget Observing (SURFRAD) network (Augustine et al., 2000). We selected three sites from this network and investigate if there is an observed diffuse irradiance discrepancy.

2. SURFRAD MEASUREMENTS

The SURFRAD sites chosen for this study include Bondville Illinois (40.06°N, 88.37°W, elev. 213 m), Desert Rock Nevada (36.626°N, 116.018°W, elev. 1007 m) and Goodwin Creek Tennessee (34.25°N, 89.87°W, elev. 98 m). These sites are at similar latitudes to the SGP site (36.605°N, 97.485°W, elev. 316 m) and together they form a triangle of sorts surrounding the Oklahoma location where the diffuse discrepancy has been observed persistently.

SURFRAD atmospheric measurements incorporated into this study include surface meteorology, radiosonde profiling data (either co--located at each site or interpolated from a nearby launching location), broadband surface albedo (from a 10 m tower), and measurements of direct and diffuse irradiance at the surface. The albedo and radiometric values are screened for cloud contamination through processing by the short wave flux (SWF) analysis (Long, 2001).

From each chosen SURFRAD location three clear-sky days (verified using from the SWF analysis) were identified. These days were specifically selected to be in the fall/winter of 2001. This is the earliest time when instrument updates at the sites were complete and all the selected sites had identical suites of radiometric instruments. This time period was also selected to be at a similar time as the latest SGP study (Powell et al., 2002) that used measurements made during fall of 2001.

3. MODEL

To model the diffuse irradiance term we used the radiative transfer code SBDART (Ricchiazzi et al., 1998). This code uses a 2 to 8-stream discrete ordinate approximation and the transmission function calculated by LOWTRAN, fit with a 3 term exponential sum. In comparison studies, SBDART has shown good agreement with other established radiative transfer models. (Barnard and Powell, 2002, Ackerman et al., 2002).

Model inputs used from the SURFRAD site include the atmospheric profiles and the broadband surface albedo. This albedo was used to scale different spectral albedos, selected based on the typical ground cover and the date of study at each of the specific sites. We note that a measurement from a 10 m tower represents the albedo for a limited field of view. The homogeneity of the surrounding land cover determines how well the 10 M tower value represents the actual scene effecting the radiometric measurements made.

For this study we had a limited availability of aerosol chemistry and measured optical properties. It is anticipated that aerosol optical depth retrievals will soon be available from the multi-filter rotating shadow band radiometers (MFRSR) already operational at each site. Additionally our continued work on this study will incorporate in-situ measurements and aerosol transport back trajectory modeling. For this initial cut analysis we elected to use an urban aerosol in our radiative transfer model. Our logic was to use the most absorbing aerosol type (single scattering albedo of ~0.8) thus producing the least amount of diffuse irradiance in our model. If we find the model still over-estimates the diffuse measurements, then whether or not the aerosol characterization is correct we have found a discrepancy. This is because putting a less absorbing aerosol type into our model will only increase the discrepancy by increasing the surface diffuse irradiance. To estimate

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aerosol optical depth we iterated our model by adjusting the aerosol optical depth until the model direct beam at the surface agrees with the actual measurement value. Because radiative models, including SBDART, are able to accurately simulate the direct term this approach is reasonable.

4. RESULTS

For the selected clear-sky days at each SURFRAD site we ran the radiative transfer model and compared the simulated diffuse irradiance to the measured values. With the exception of one case, the modeled results were consistently higher than the measurements on average by 7 Wm^{-2} or less. Shown in table 1. are the case examples as well as the results from the latest study at SGP (Powell et al., 2002). The daily averages represent 4 to 8 hours centered around local noon.

Table 1. Diffuse Term Difference (model-measurement)

Site	Date	$\sim\tau_{aer}$	Ave Δ (Wm^{-2})
SGP	09-25-01	0.05	5
SGP	09-28-01	0.15	7
SGP	09-29-01	0.10	6
Bondville	11-03-01	0.07	5
Bondville	12-29-01	0.05	5
Desert Rock	09-07-01	0.02	2
Desert Rock	11-08-01	0.02	-3
Goodwin Creek	10-29-01	0.05	7
Goodwin Creek	11-25-01	0.03	6

5. FUTURE WORK

The results of this study suggest that diffuse discrepancy is not limited to the SGP location. We will be continuing this study with a more thorough characterization of aerosol and surface albedo and with the addition of more days and cases with greater aerosol loading.

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