Five Years of Clear-Sky Solar Radiation Measurements and Aerosol Forcing at the SGP ARM Site

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Introduction

The Atmospheric Radiation Measurement (ARM) Program Southern Great Plains (SGP) Cloud and Radiation Testbed (CART) site has been collecting high-quality surface radiative flux measurements for over five years. The array of radiometers and other atmospheric instrumentation provides an excellent opportunity for intercomparison studies involving the instruments and radiative transfer models. One of our studies has focused on the measurements of surface solar irradiances in 3604 clear-sky 30-min. segments from January 1994 to September 1998. Careful consideration is given to the elimination of cloud contamination effects. Water vapor profiles from radiosondes and the microwave radiometer and aerosol optical depths measured at five wavelengths are input to the Fu-Liou radiative transfer model to provide a comparison with measurements.

For the direct beam, the model agrees well with the measured surface irradiances with a mean excess of 2.4 W m^{-2}. An unexpected correlation was found between the model-measured direct irradiance difference and the surface air temperature, suggesting an uncorrected temperature effect in the pyrheliometer output. The modeled mean diffuse irradiance is still overestimated by 14.0 W m^{-2} after applying a correction for the night-time offset problem that is endemic to pyranometers.

Various hypotheses are examined to explain the diffuse discrepancy including modified aerosol properties or the presence of an unaccounted gas absorber. Although a number of hypotheses are still viable to explain the model-measured diffuse difference, the mean top of atmosphere (TOA) aerosol forcing ranges from -11.5 W m^{-2} to -1.4 W m^{-2} between the various hypotheses. Our study does not support the idea of a water vapor continuum in the solar wavelengths to explain any significant portion of the observed bias. A five-year climatology of the aerosol optical depth and Angstrom exponent is presented showing seasonal and annual trends. An increase in the Angstrom exponent from 1994 is observed in both the surface-based aerosol optical depth measurements and in the SAGE II satellite data.

Acknowledgments

The research work contained herein has been supported by U.S. Department of Energy Grant DE-FG02-97ER62363.