Expansion of the CAGEX Database with a Network of Surface Radiometers and Aircraft Measurements in the ARM Enhanced Shortwave Experiment: Forthcoming Helicopter Measurements of BDRF Over the Southern Great Plains Cloud and Radiation Testbed Site

T. L. Alberta, R. C. DiPasquale, F. G. Rose, W. L. Smith, Jr.
Analytical Services and Materials, Inc.
Hampton, Virginia

T. P. Charlock, C. H. Whitlock, G. L. Schuster, P. Minnis
NASA Langley Research Center
Hampton, Virginia

Introduction

The CERES/ARM/GEWEX Experiment (CAGEX) was originally designed to test, develop, and validate retrievals of the Clouds and the Earth's Radiant Energy System (CERES) Surface and Atmospheric Radiation Budget (SARB), and to make the data set available to the scientific community. CAGEX basically consists of input to the Fu and Liou (1993) δ-four stream radiative transfer code, output from the code in the form of longwave and shortwave flux profiles, and surface and top-of-atmosphere measurements, used to validate the code. The Atmospheric Radiation Measurement Program (ARM) provides an excellent platform upon which to collect both input and validation.

The first CAGEX effort, version 1 (Charlock and Alberta 1996) concentrated on a 26-day period in April of 1994 (April 5-30). Fluxes were calculated in 18 half-hourly time steps, which spanned a significant portion of the day. The conclusions from version 1 can be summarized by noting a bias in the shortwave insolation and atmospheric absorption. The Fu and Liou code consistently overestimated the downwelling flux at the surface. This overestimation is present in both clear and all-sky conditions. In the longwave, flux biases at the surface and top-of-atmosphere were largely driven by the input soundings and skin temperature. These findings underscore the importance of accurate input to the code to obtain accurate longwave fluxes.

Version 2 of CAGEX is a follow-up to version 1. The spatial grid and vertical resolution remain the same, but the time period studied covers the October 1995 ARM Enhanced Shortwave Experiment (ARESE) campaign. In version 2, an attempt will be made to isolate some of the biases found in the version l data, using a new complement of instrumentation which was made available at the ARM Southern Great Plains (SGP) Cloud and Radiation Testbed (CART) site in October of 1995. The remainder of this document will focus on the tools CAGEX will use for version 2, and show some preliminary results.

Components of CAGEX Version 2

Input to the Fu and Liou code consists of temperature, humidity, ozone, and aerosol soundings, surface albedos and emissivities, the solar constant, the cosine of the solar zenith angle, skin temperature, cloud fraction, cloud top and bottom temperatures, and optical depths. CAGEX will assign a "core" dataset for each of these parameters, and include variations based on the availability of additional datasets. The current core dataset is described in the following paragraph.

Temperatures are interpolated from ARM sondes from the surface to 100 mb. Above 100 mb, TOVS temperatures are used. Humidities from the surface to 300 mb are also from the sondes. Above 300 mb, SAGE climatology is used.

SBUV2 ozone is the current core dataset, but we will probably switch to the ARM ozone sondes once the data is processed. A limited representation of aerosol column optical depths have been obtained from the ARM Baseline Surface Radiation Network (BSRN) multi-filter rotating shadowband radiometer (Harrison et al. 1994; Dr. Joseph Michalsky, personal communication, 1995), as well as d'Almeida et al. (1991) tables for single-scattering albedos, asymmetry parameters, and extinction coefficients, all of which are functions of relative humidity and wavelength. A profile for ocean aerosols (Spinhirne 1993) is used to weight the vertical distribution. We anticipate many changes to the aerosol dataset as more data become available. Surface albedos were derived from five sets of pyranometer-based radiometry measurements in the CAGEX central gridbox. For the eight outlying grid boxes, these albedos are weighted by the narrowband clear-sky albedos supplied by the cloud group here at NASA Langley (Minnis et al. 1995). Spectral reflectances, the actual input to the Fu-Liou code, are derived using the reported shape of spectral reflectance in a sort grass meadow (Brieglib et al. 1986). The solar zenith angle is calculated as a 30-minute average of the cosine, centered on the CAGEX time step. The solar constant is 1365 W/m**^{2}, adjusted for the day of the year, and for the spectral range of the radiometry. The version 2 core skin temperature is simply the sounding surface temperature. However, we also plan to utilize the ARM SMOS surface temperatures and pyrgeometer-based skin temperatures in our analysis. Currently we are assuming a black surface (emissivity = 1). The cloud properties are obtained from the ARM GOES-8 LBTM retrievals (Minnis et al. 1995). Properties include amount, top and bottom temperatures, and optical depths. A particle size is prescribed (10 microns for water, 35 microns for ice).

The above sets of data describe the current core of the CAGEX input. Many other datasets are available, including cloud radars, ceilometers, and micropulse lidar for cloud base, NCEP Eta sounding, AERI low-level water vapor, microwave radiometer water vapor and liquid water, and several radiometry sites. These data will be used both in input for and validation of the Fu-Liou code. We also anticipate the use of other radiative transfer codes to calculate fluxes.

Preliminary Results

At the time of this writing, CAGEX version 2 is in its preliminary stages. Hence, few results are available. The core dataset has been run through the Fu and Liou code, however, and some clear-sky daytime results are complete. Figure 1a shows measured clear-sky shortwave insolation plotted against calculated insolation. Immediately apparent is the overestimation of calculated shortwave flux as compared to an measured pyranometer-based flux, which is the average of five radiometry sites present in the central CAGEX grid

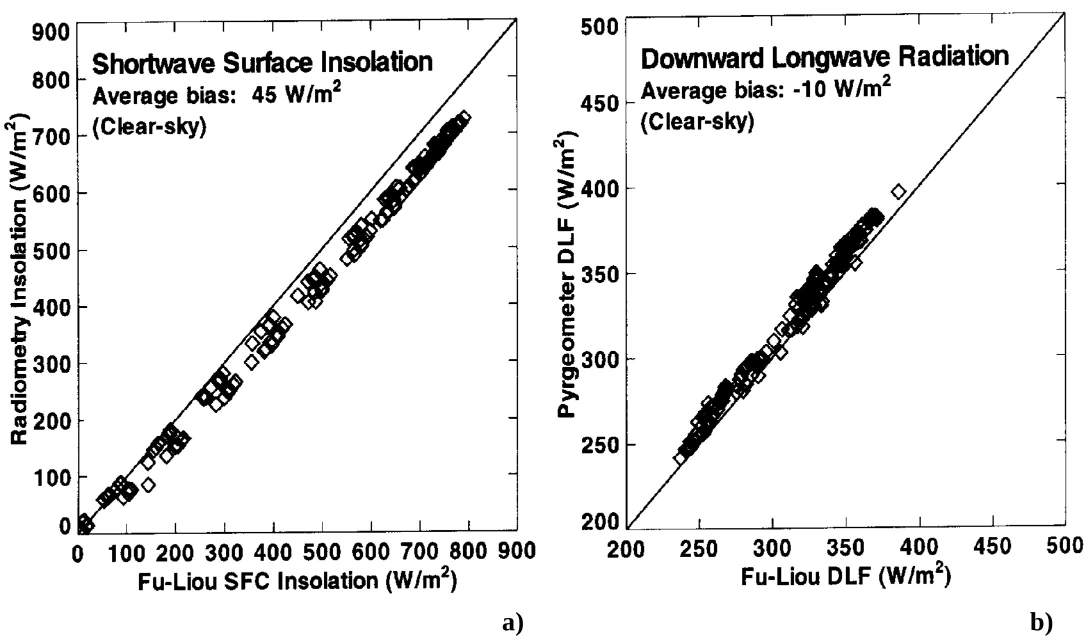

Figure 1. CAGEX version 2 clear-sky results: a) Clear-sky shortwave surface insolation, measured vs. calculated. b) Same as a, for downward longwave radiation.

cell. Using available data at the ARM SGP CART Site, we hope to determine a possible cause of this overestimation.

Downward longwave flux (DLF) at the surface also shows a bias (Figure lb). Calculations show an underestimation of DLF when compared with pyrgeometer measurements, indicating the code is absorbing less longwave radiation in the atmospheric column than would be expected, based on measured fluxes. This bias will be examined by utilizing several sources of water vapor and low-level temperatures, available at the SGP site.

The complete set of atmospheric flux profiles will be available when version 2 is officially released, sometime during the summer of 1996. The results shown here should be interpreted with caution. In the near future, we will be examining other available datasets to determine what we will ultimately use for the CAGEX core dataset.

Conclusion

CAGEX version 2 has been described, and a sample of the preliminary results has been presented. We found biases in longwave and shortwave downwelling irradiances at the surface, both of which suggest the radiative transfer code is not absorbing enough radiation in the atmosphere.

Version 2 of CAGEX will be made available to outside users sometime during the summer of 1996. Access will be through the same channels as the first version of CAGEX, http://snowdog.larc.nasa.gov:8081/cagex.html. Progress on Version 2 will begin to appear on the CAGEX web page soon.

Acknowledgments

CAGEX would not be possible without the collaboration of many people who supplied us with data as well as many who offered their insight into several of the questions that have resulted from our effort: Qiang Fu, Kuo-Nan Liou, John DeLuisi, Jim Spinhirne, Joseph Michalsky, Shi-Keng Yang, Ron Nagatani, Evgeney Yarosh, Bruce Wielicki, Bruce Barkstrom, Dave Randall, Gerry Stokes, and Peter Minnett. As version 2 develops further, this list will undoubtedly expand.

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