P1.11 SEASONAL RADIATION BALANCE OF AFRICA

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1. Introduction

Africa has a range of climate classes, from desert and savanna to rain forest (e.g. Trewartha and Horn, 1980). Due to the low latitude of Africa, the climate is dominated by intense radiative interactions. The Sahara Desert covers most of North Africa and the Kalahari Desert much of South Africa. The importance of radiation in the formation and maintenance of the deserts was described by Charney (1975). Equatorial Africa contains the Congo Basin, which is tropical rain forest. Neelin and Held (1987) and Srinivasan (2001) explained the role of radiation in sustaining tropical convection. For much of the continent, monsoons account for most of the rain. The intertropical convergence zone (ITCZ) moves seasonally to bring the monsoons, i.e. the ITCZ "follows" the Sun, in response to the radiative forcing. In essence, the weather and climate system is a heat engine, driven by radiation.

Because of the importance of radiation in weather and climate, the Earth Radiation Budget Experiment (Barkstrom and Smith, 1986) measured "top of atmosphere" (TOA) radiative fluxes for the period 1985-1990 with 2.5° resolution (using scanning radiometers) and for 1985-1999 with 5° resolution (using longer-lived nonscanning radiometers). The Surface Radiation Budget (SRB) program used meteorological satellite data to compute radiative fluxes at the surface, globally for 1985-1992. The Clouds and Earth Radiant Energy System (CERES) program (Barkstrom, 1990; Wielicki et al., 1996) flew CERES instruments on the Tropical Rainfall Measuring Mission (TRMM), the TERRA and AQUA spacecraft.

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In addition to measuring the radiative fluxes at TOA, the CERES project derives radiative fluxes at the surface and at selected levels in the atmosphere. This paper presents maps of radiation fluxes over Africa and discusses their relations to the climate processes. The data provide global coverage, so that any geographical area can be examined.

ERBE, SRB and CERES data are available from the Atmospheric Sciences Data Center of Langley Research Center via the web at http://eosweb.larc.nasa.gov

2. Radiation Maps

Figure 1a shows the monthly-mean reflected shortwave radiative flux (RSR) over Africa on a 2.5°x2.5° grid for January 2001, when the Sun is over the Kalahari Desert. The maximum RSR (greater than 170 W-m^{-2}) is due to the deep convective cloud system over the southern part of the Congo Basin. The southern border of the map shows the high RSR of the clouds at 40°S, the "Roaring Forties." The minima are clear regions, where ocean and vegetated surfaces reflect little radiation (less than 80 W-m^{-2}. The Sahara and Kalahari Deserts have intermediate levels of RSR (95 to 125 W-m^{-2}). Figure 1b shows RSR for July 2001, when the Sun is over the Sahara Desert. The maxima are over western Africa, where the monsoon is active. Minima are over oceans and southern Africa, where reduced insolation and cloud cover result in low RSR.

Figure 2a shows the monthly-mean outgoing longwave radiative flux (OLR) over Africa for January 2001. The minimum OLR is over the deep convective region over the southern Congo Basin, where the OLR is less than 210 W-m^{-2}, due to the high cold cloud tops. The clear areas, which had low RSR, have OLR exceeding 285 W-m^{-2}. Figure 2b shows monthly-mean OLR for July 2001. The Sun is over the Sahara Desert, where the OLR

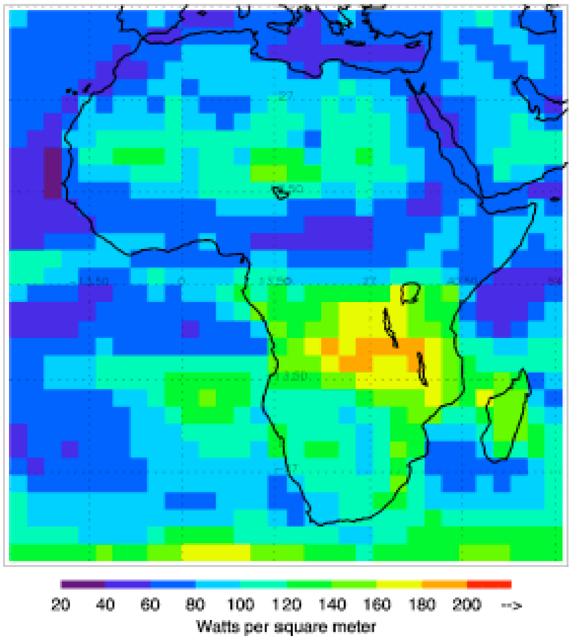

Figure 1a. Monthly-mean reflected shortwave radiative flux over Africa in January 2001.

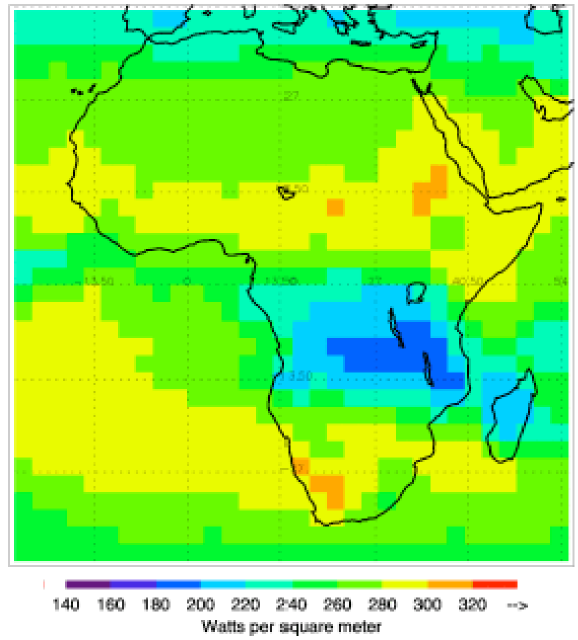

Figure 2a. Monthly-mean longwave radiative flux over Africa in January 2001.

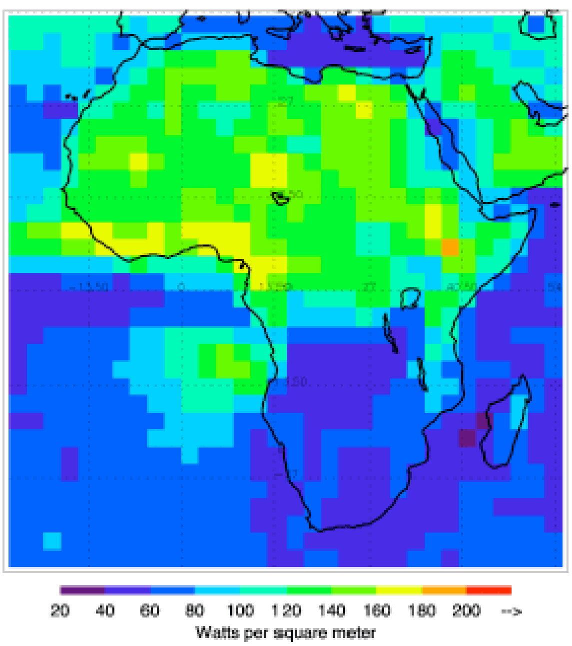

Figure 1b. Monthly-mean reflected shortwave radiative flux over Africa in July 2001.

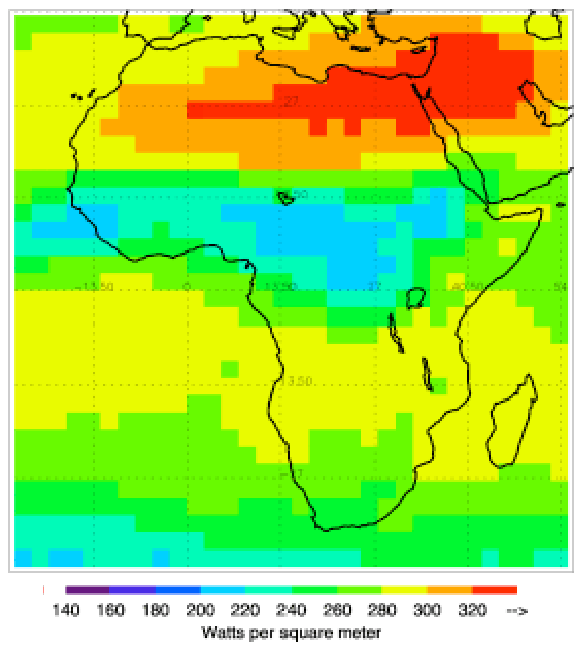

Figure 2b. Monthly-mean longwave radiative flux over Africa in July 2001.

exceeds 300 W-m^{-2}. The minimum OLR is near 10°N, where the ITCZ has moved northward to bring the monsoon to these areas.

The insolation at the top of the atmosphere is computed from the solar output, the Earth-Sun distance and the solar declination. The absorbed solar radiative flux is the insolation minus the reflected solar radiative flux, and the net flux is the absorbed solar radiation minus the outgoing long-wave radiative flux. The net flux is shown in fig. 3a for January 2001. Every region northward of 10°N has a net radiation loss, and the Sahara Desert has minima of -60 W-m^{-2}. The South Atlantic and Indian Oceans and parts of south Africa have net radiation greater than 100 W-m^{-2}. Figure 3b shows the net radiation for July 2001.

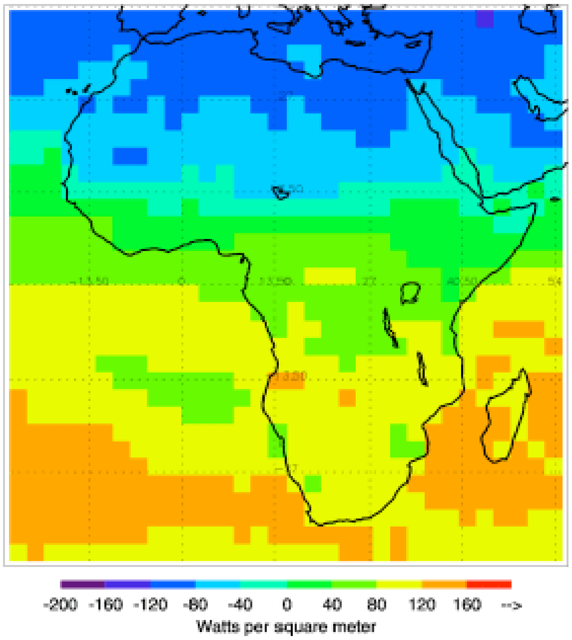

Figure 3a. Monthly-mean net radiative flux over Africa in January 2001.

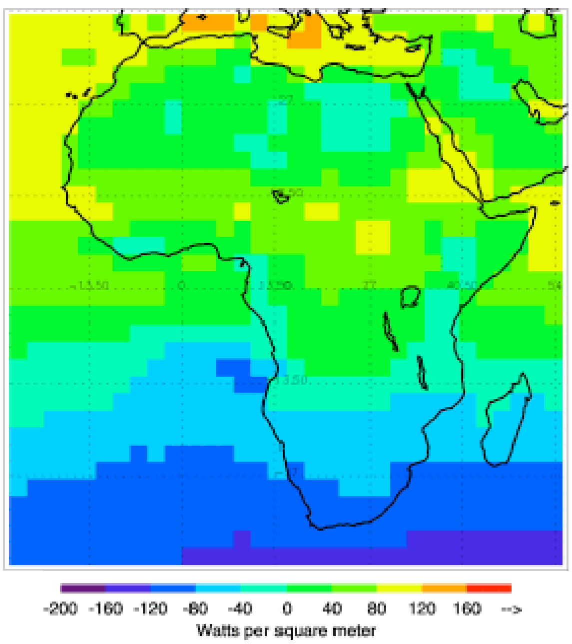

Figure 3b. Monthly-mean net radiative flux over Africa in July 2001.

The Mediterranean Sea has the maximum net radiation, exceeding 100 W-m^{-2}. The Sahara Desert has a net radiation near zero over its expanse. The monsoons over the savanna region north of the Equator have net radiation greater than 60 W-m^{-2}. This energy source serves to drive the convection required for the monsoon. Southward of 15° the net radiation is negative.

3. Concluding Remarks

The maps discussed here were produced using data from the CERES/TERRA instrument. In the near future these data will be used to develop a 1° spatial resolution data set. Interannual variations can be studied using the 15-year ERBE data set, which spans from 1985 through 1999 (Bush et al., 2002).

This paper has discussed only radiation data sets. In the study of weather and climate processes, data sets of other parameters would be used. The AQUA spacecraft is now operational, with CERES instruments to provide additional measurements of Earth radiation. Also, the first MeteoSat Second Generation (MSG) satellite has been placed into orbit. In addition to the SEVIRI, the primary instrument, the spacecraft carries a Geosynchronous Earth Radiation Budget (GERB) instrument for making broadband measurements of the Earth's radiation balance. In the near future these data will become available. The MSG is ideally located for studies of African weather and climate processes.

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