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Estimation of the Incident Solar Radiation by Radiative Transfer Model During SCAR-B

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ABSTRACT

GOES-8 satellite data is used in association with a radiative transfer model to estimate the surface solar radiation in Brazil. The model employs a very crude aproximation to deal with the aerossols. The purpose of this work is to use surface radiation data, and aerosol data, gathered by the SCAR-B mission to test this model in hilghly biomass burnin areas of Brazil during the dry season.

INTRODUCTION

Although most of Brazil its within the tropic sunbelt, solar energy is yet poorly utilized here. Many state energy utilities companies, and the government itself (Eletrobras), are keen to foster the development of this kind of clean, renewable energy source. For example, the Brazilian Center for Research in Electrical Energy (CEPEL/Eletrobras) has undertaken a cooperative research with the northern states (Pernanbuco, Ceara, Amazonas, Pará, Acre, Bahia, Minas Geraes and Alagoas) to evaluate a pilot project of stand-alone solar home systems (Ribeiro et al, 1995). These regions are mostly low population rural areas where the supply of grid energy is not cost-effective. Yet, this simple form of electric energy supply will bring development and more contort to these population by lighting public schools and houses.

In order to make a better use of this energy in Brazil an evaluation of the surface solar radiation is needed, and this is a difficult task such a large territory of more than 8.5×10^6 km^2. This information is needed for example, when it comes to finding a profitable market of solar home heating, and also to develop large solar power plants in Brazil. The extrapolation of solar data between the existing ground stations is hampered by its very reduced number, and also by its uneven distribution. Large areas of Brazil are almost dataless as far as solar energy is concerned. Most of the surface solar radiation data available today came from crude estimates made by the duration of sunlight (Nunes, et al, 1979)

Since 1994 the Brazilian National Institute for Space Research (INPE) and the State University of Santa Catarina (UFSC), in collaboration with the GKSS(Germany), are undertaking a joint program to implement a radiation transfer model to produce monthly charts of surface solar radiation by use of geostationary satellite GOES-8 data in the visible channel. This model was originally developed by Möser and Raschke [1983] and modified by Stuhlmann et al., [1990]. It was tested with METEOSAT-2 data in Brazil for the years of 1985-86 (Pereira et al, 1996). A modified version for the GOES-8 is now in a validation stage.

RESULTS

The primary assumption of this model is that clouds are the most important perturbing component for the radiation field. Other perturbing factors such as aerosols, water vapor, ozone and surface albedo are considered second order processes and are treated by using monthly, mean climatological values for these variables.

The model initially calculates from satellite data the normalized upward radiance L_{eff} by the ratio $(L - L_{min}) / (L_{max} - L_{min})$, where L stands for the actually measured upward radiance taken in the spectral range of the geostationary satellite. The subscripts indicate monthly mean maximum values (overcast conditions) and minimum values (clear sky conditions). Maps of minimum upward radiances, L_{min}, were calculated by storing for each solar zenith angle the lowest value of every pixel during one month. Maximum upward radiances, L_{max}, were chosen from typical radiances reflected from optically thick cloud decks for each pixel location. For each pixel L_{eff} can be interpreted as the effective fractional cloud cover and it is dimensionless. By assuming that the following linear relation holds: $1 - L_{eff} \approx (\phi - \phi_{min}) / (\phi_{max} - \phi_{min})$, where ϕ is the broadband surface radiation flux, the following parameterization holds: $\phi = \{(1 - L_{eff}).[\tau_{clr} - \tau_{cld}] + \tau_{cld}\}.S_o\mu_o$. The model applies a radiative transfer scheme, developed by Schmetz [1984], based on a two-stream approximation, in order to estimate the boundary conditions broadband transmmitances for clear (τ_{clr})and cloudy sky (τ_{cld}.)

The estimations of the model are being compared with the results obtained from the ground radiation data from the LABSOLAR/UFSC with good results, as seen in Table 1 for 1994.

Table 1

month	valid images	RMSE(%)	MBE (Wh/m^2)
July	169	10.0	-23.74
October	158	17.6	-348.9
November	118	16.2	265.2
December	93	16.1	453.8
all months	538	16.1	242.9

COMMENTS

The model now requires a validation with ground data in order to adjust some of its parameters (eg. albedo, aerosols). As far as the aerosols are concerned, the model employs a very crude approximation for its distribution in the atmosphere based on the horizontal visibility at surface levels The horizontal visibility is given by a prescribed map that assumes only the variation with latitude and with the time of year (from 6 to 50 km). To take into account the change in the boundary layer depending on the surface elevation, the horizontal visibility is increased exponentially to a maximum value of 150 km for a level of 2000 m This simple approach has proven to be adequate in most cases. Nevertheless, the discrepancies between model predictions and ground results in biomass burning regions of Brazil during the dry season remains unknown.

The goal of this work is to validate and adjust the model with ground radiation data obtained by other research groups during the SCAR-B mission. It is also our goal to improve the model as far as the aerosols are concerned by either adjusting the prescribed map of horizontal visibility or by improving the handling of the aerosols by the model.

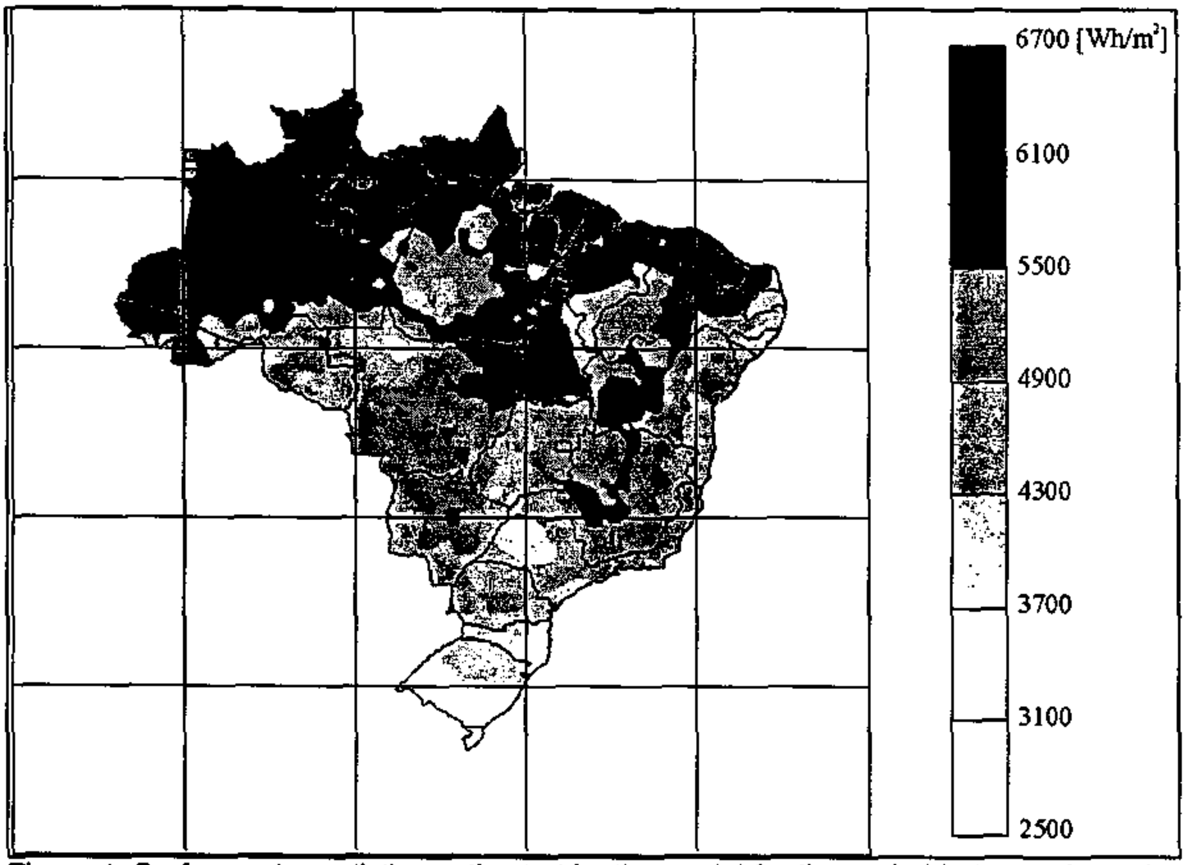

Figure 1. Surface solar radiation estimated by the model for the period between August 15 and September 15, 1995.

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