

2nd Workshop on Satellites for Solar Energy Assessments February 3-4, 1999

Presentations

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Presentations

Solar Radiation Measurements in Brazil by Using Satellite Techniques

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A radiation model originally developed in Germany (GKSS-Geesthacht) was adapted and improved to operate in Brazil by a joint collaboration between the Federal University of Santa Catarina (UFSC) and the Brazilian National Institute for Space Research (INPE). It is a physical model that employs the visible narrow-band response of a geostationary satellite to estimate the broadband solar radiation at surface. The model was validated by using surface pyranometers and is in operation since 1995. The first edition of Brazilian national Satellite Atlas of Solar Radiation has just being issued in conjunction with the Brazilian National Institute of Meteorology (INMET). This presentation is a review of this model, the latest improvements, and the main results of its application in Brazil. The model is being improved to take into account some local environmental characteristics that are only poorly assessed so far. The intensive cloud convection which is associated with the inter-tropical con-

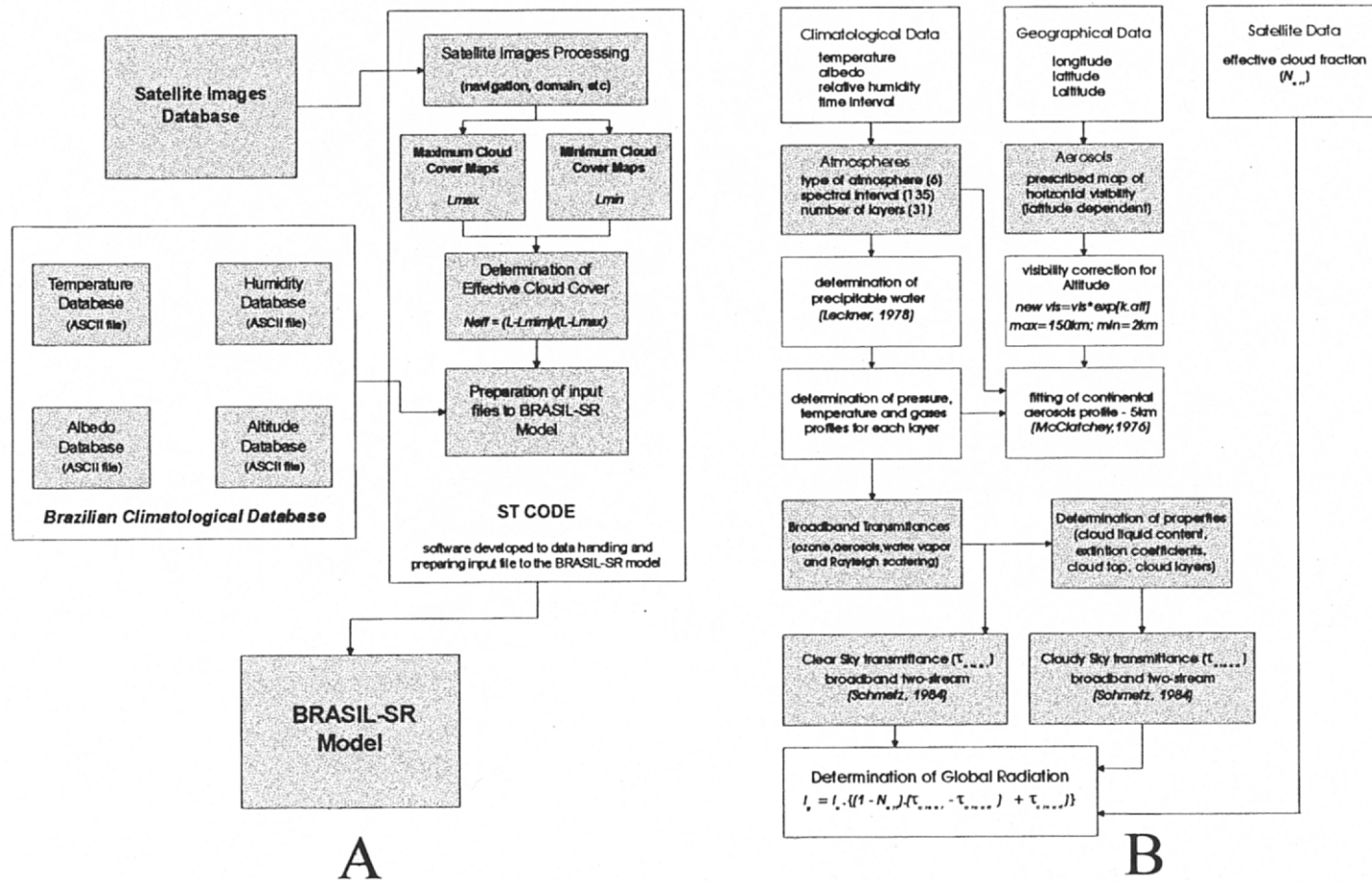
vergence zone (ITCZ); and the manmade changes in the biosphere-atmosphere interaction, triggered by deforestation and land clearings are among the most important factors. The development of specific procedures of cloud screening and surface validation of cloud fraction will be described. In addition, it will be reported the first results of a study aimed at the estimation of the effects of biomass burning combustion byproducts injected into the atmosphere by the widely used practice of land clearings for farming and cattle growth. The magnitude of this effect, however, remains a controversial issue particularly as regards to the aerosols.

This work was made possible by grants from FAPESP, CELESC, and CNPq.

Block diagrams of the BRASIL-SR satellite model

(A) Input of satellite data and model parameters

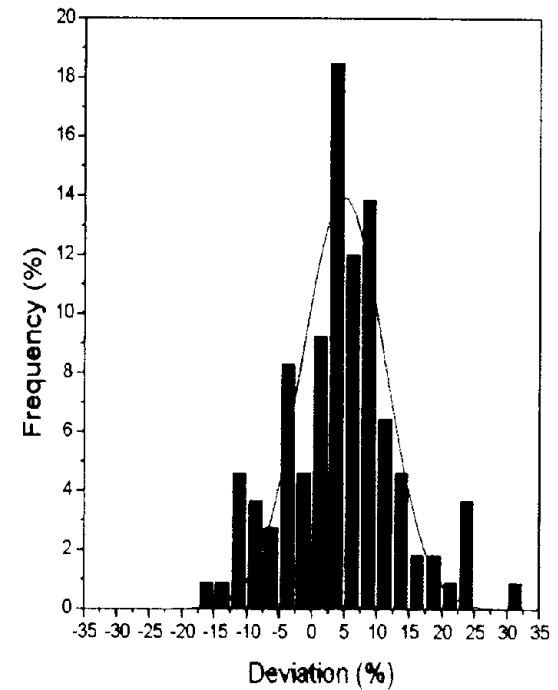
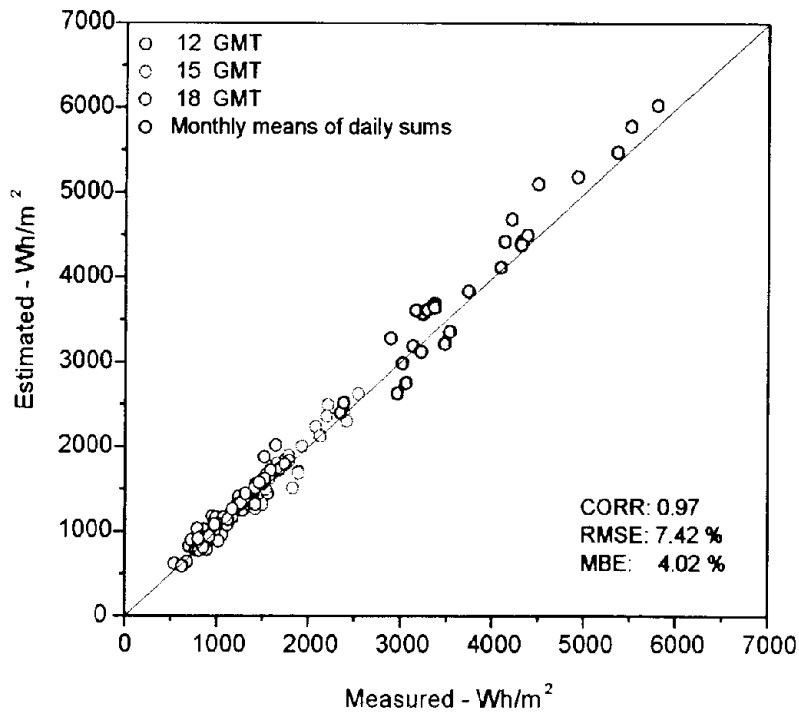
(B) Radiation transfer model



Model versus measured solar irradiation

BSRN - Florianópolis (27.60° S 48.57° W)

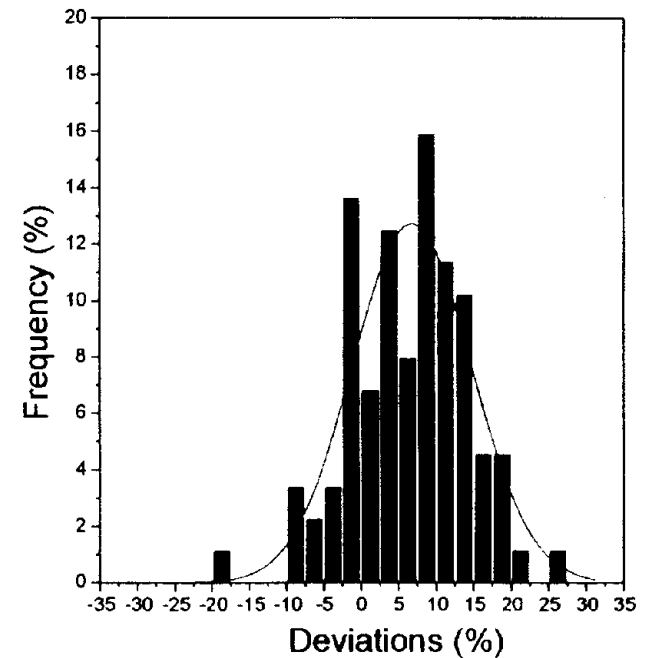
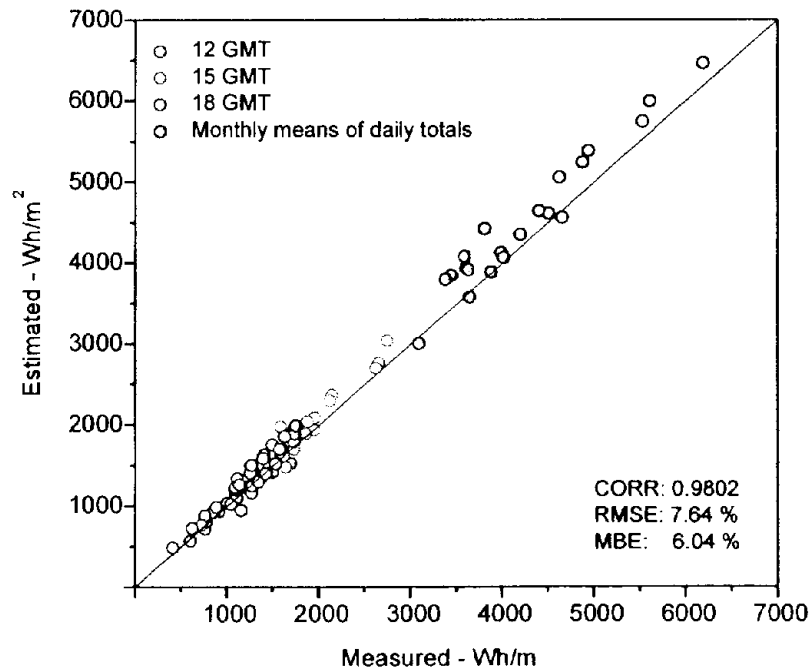
altitude 10 m



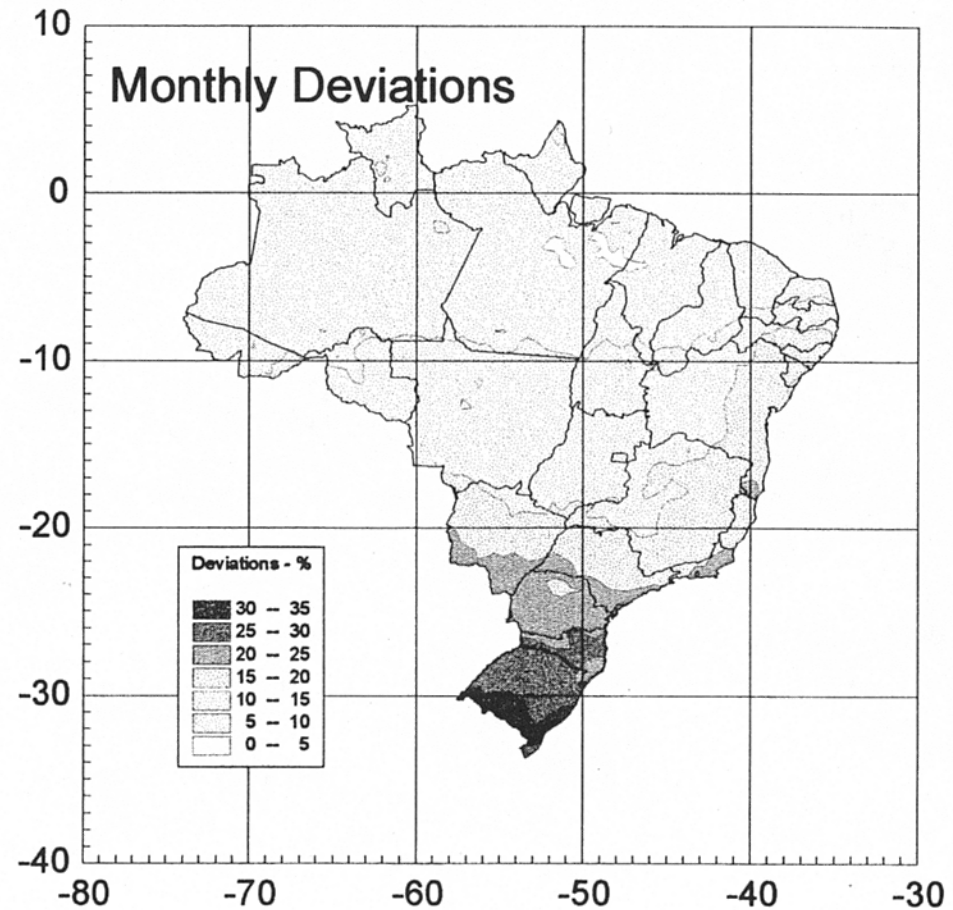
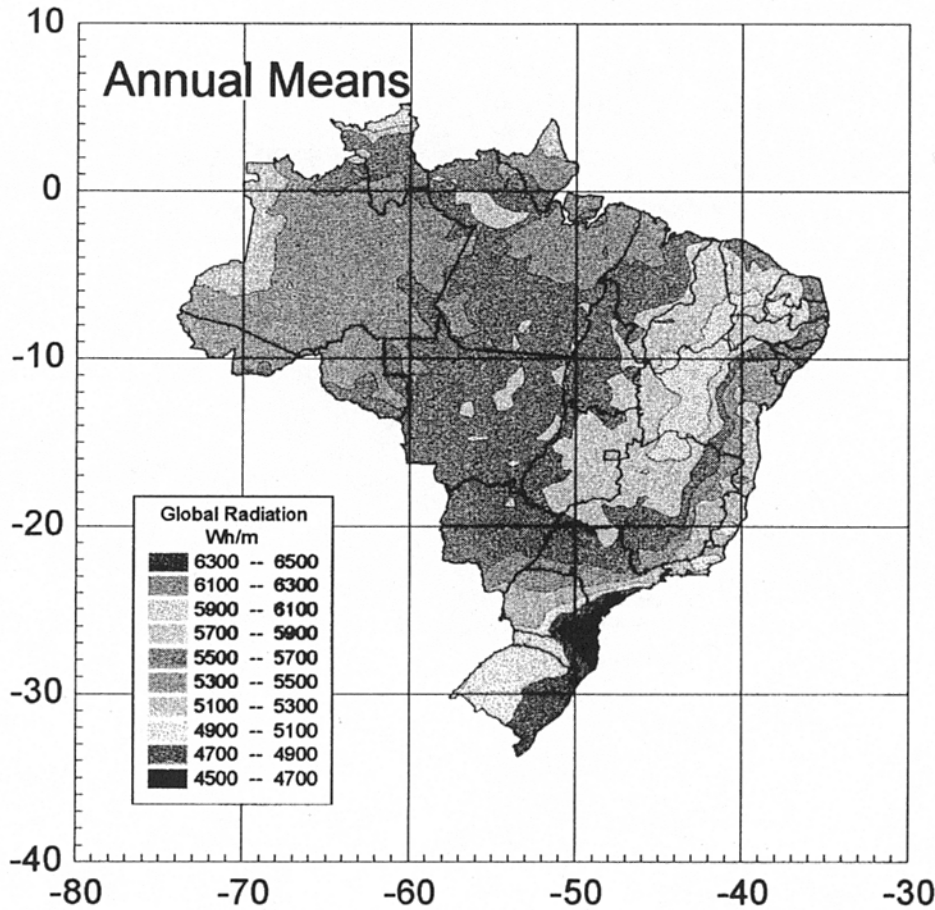
Model versus measured solar irradiation

Lebon Regis (26.98° S 50.71° W)

altitude 1036 m

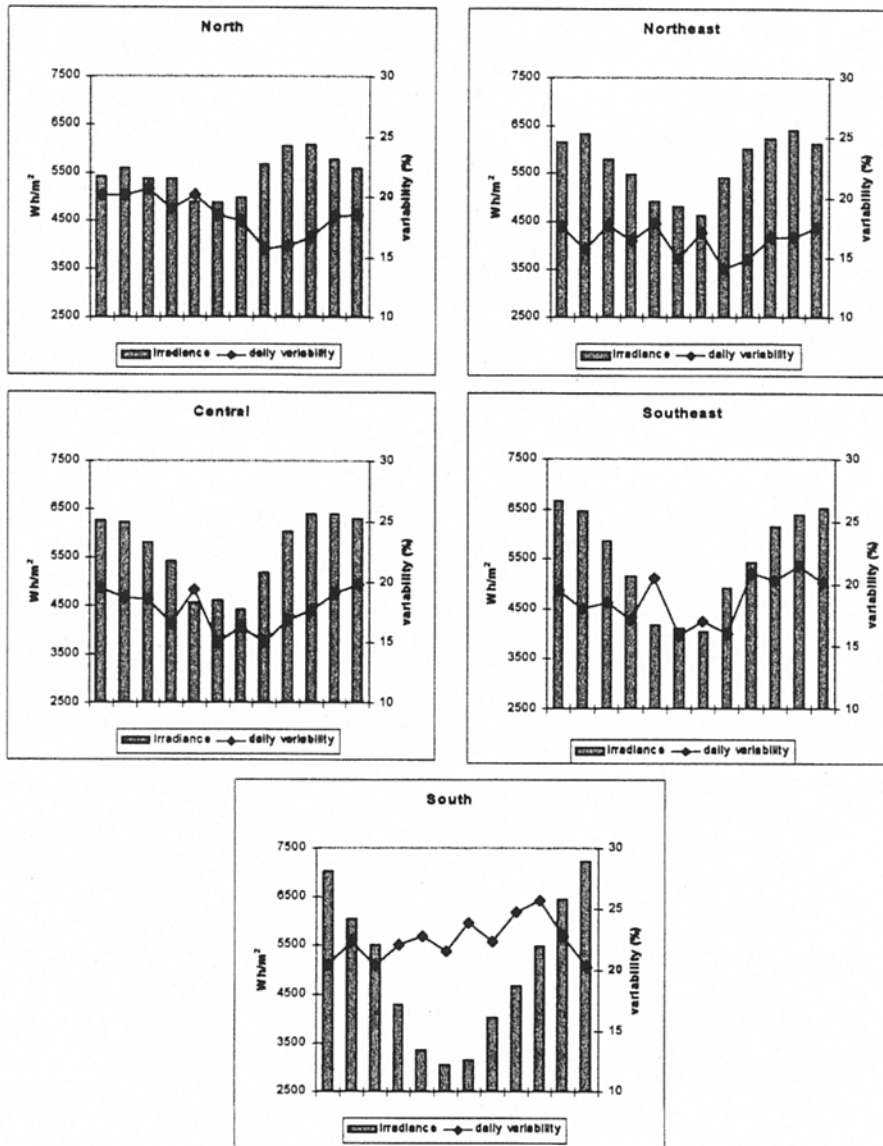


Mean Annual Global Horizontal Solar Irradiation and Monthly Deviations from the Annual Mean

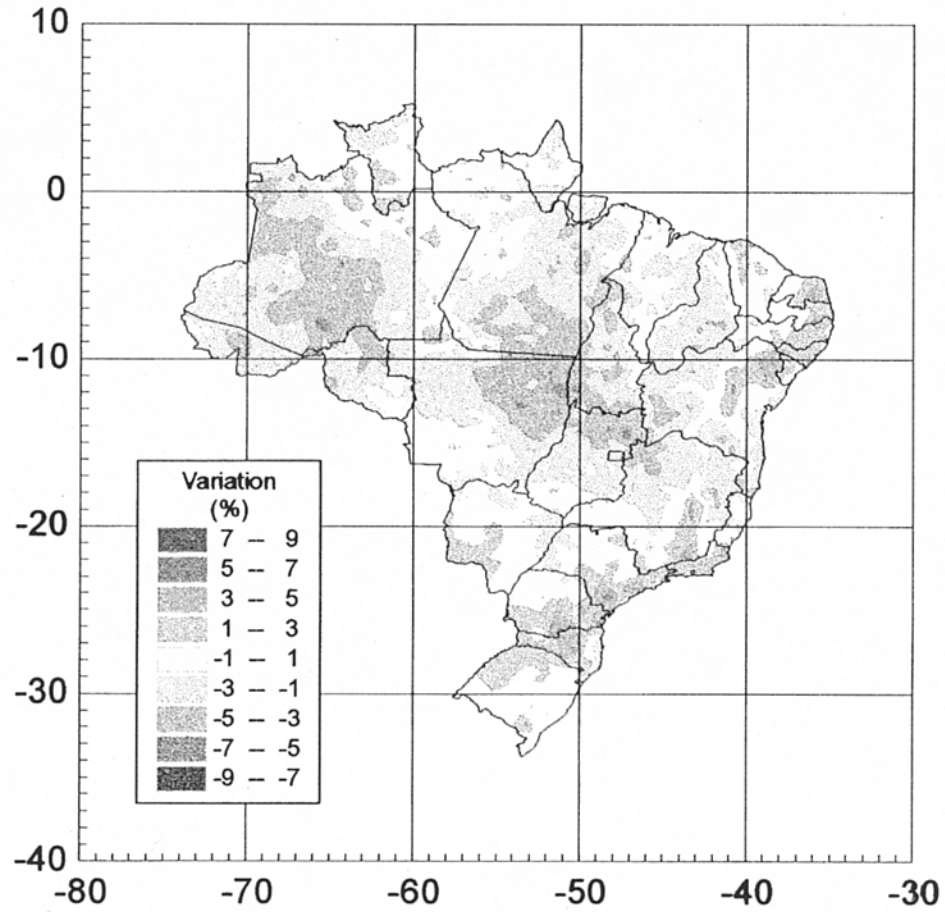


Regional Variability of the Solar Irradiation

(for the five main climatic areas of Brazil)

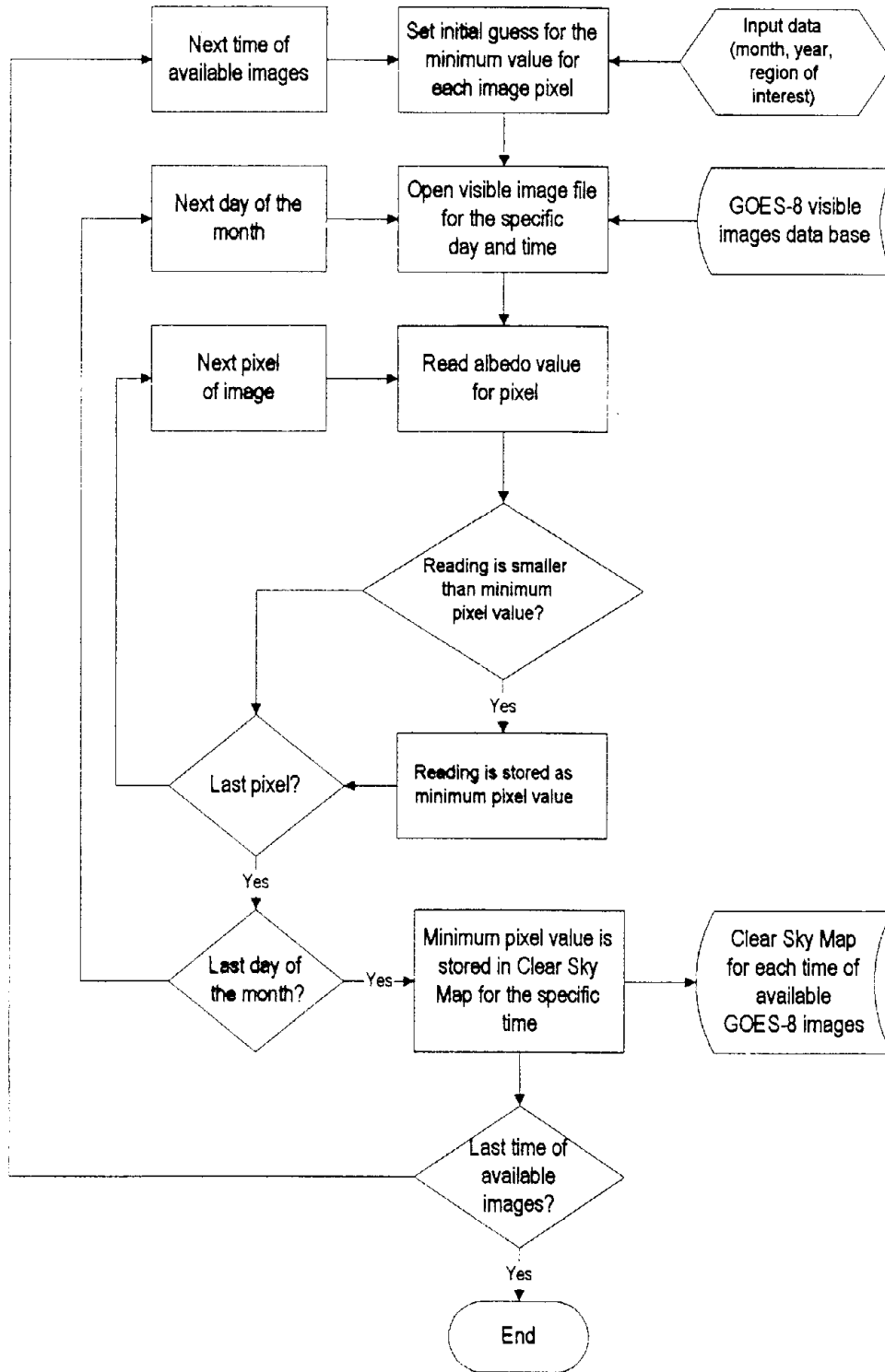


Inter-annual Relative Variability (1996 - 1997)



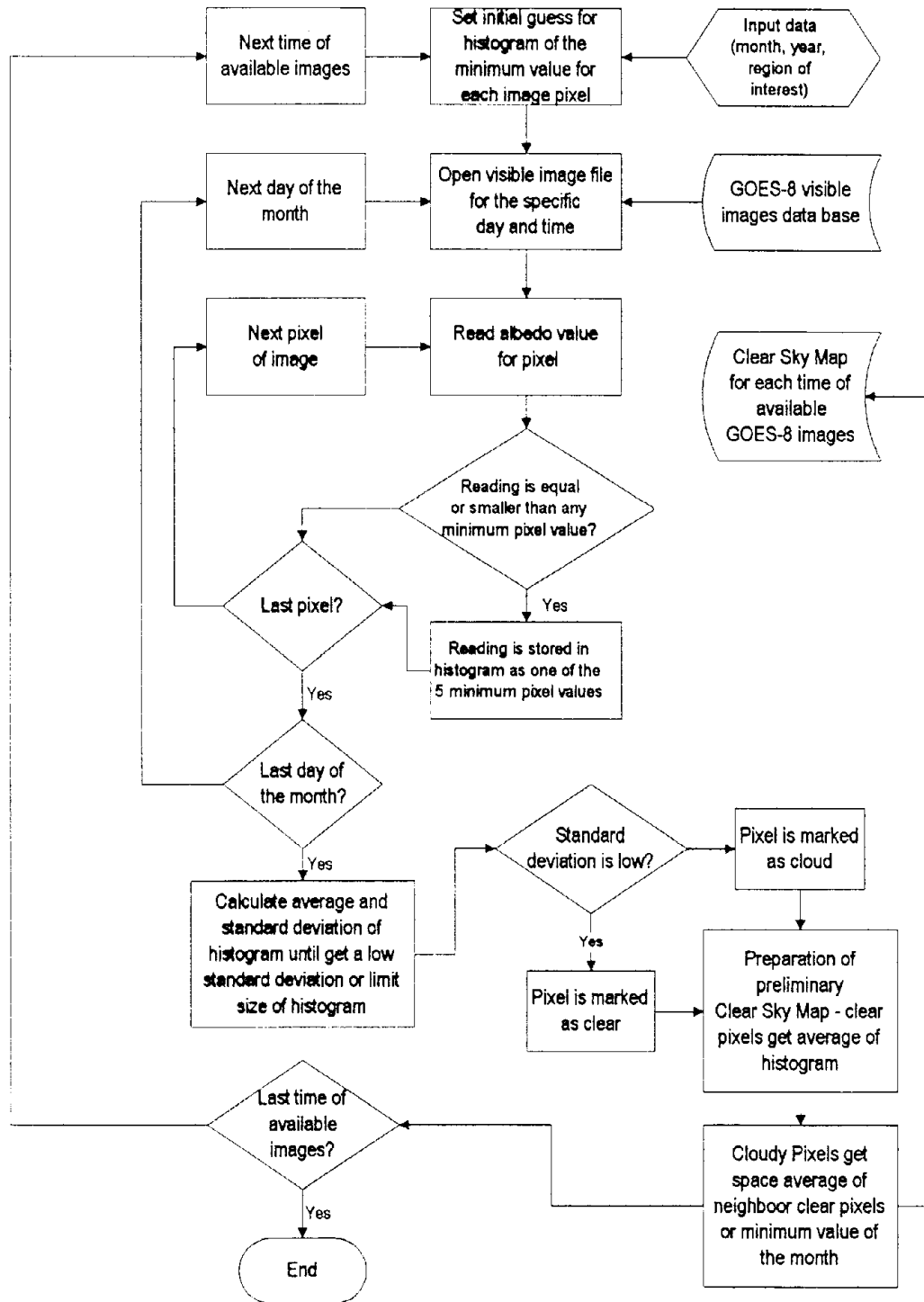
Block Diagrams of Clear Sky Composite Image

Minimum visible value - Method #1 (Standard in BRASIL-SR)



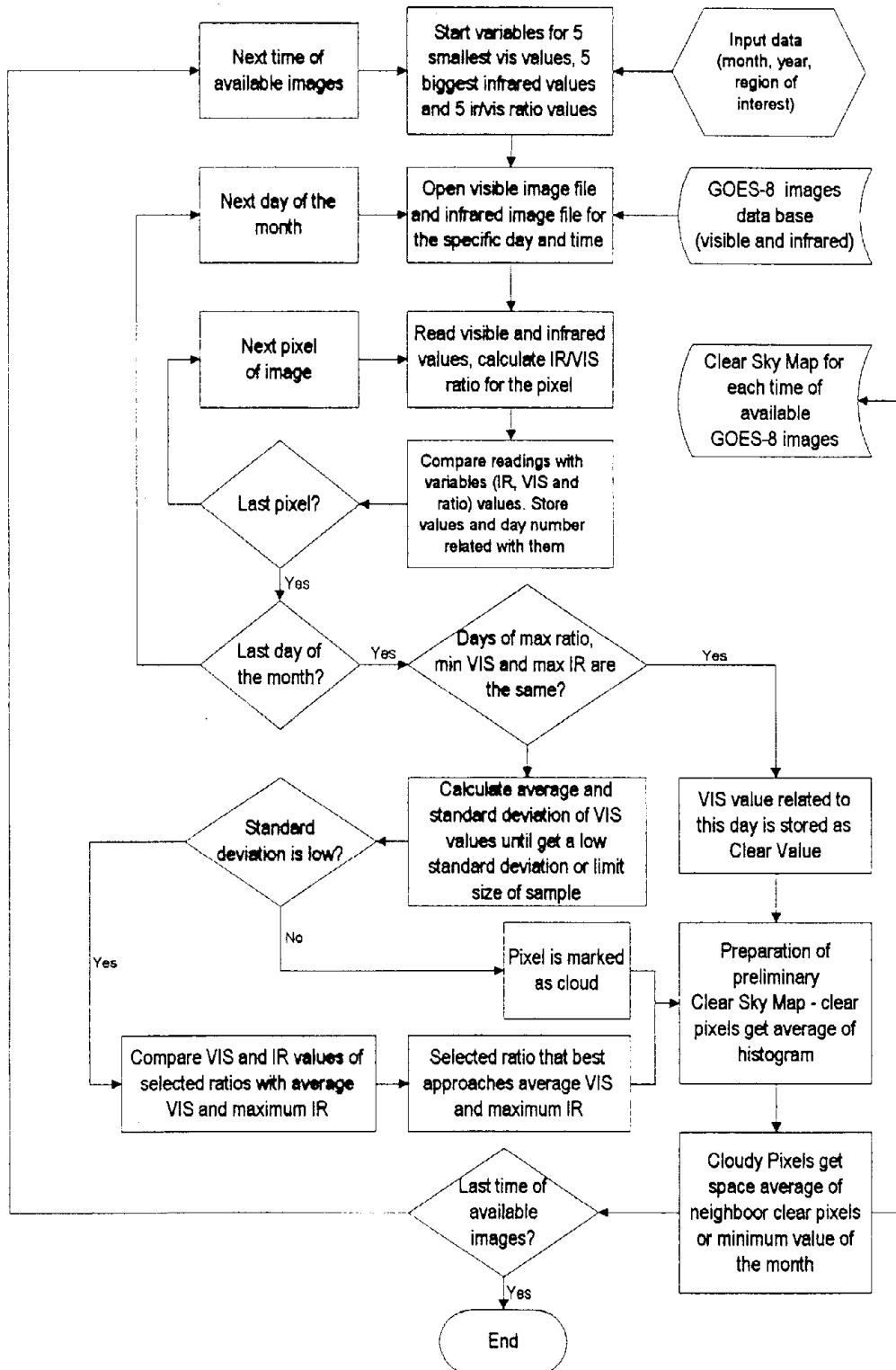
Block Diagrams of Clear Sky Composite Image

Average of five smallest visible values - Method #2



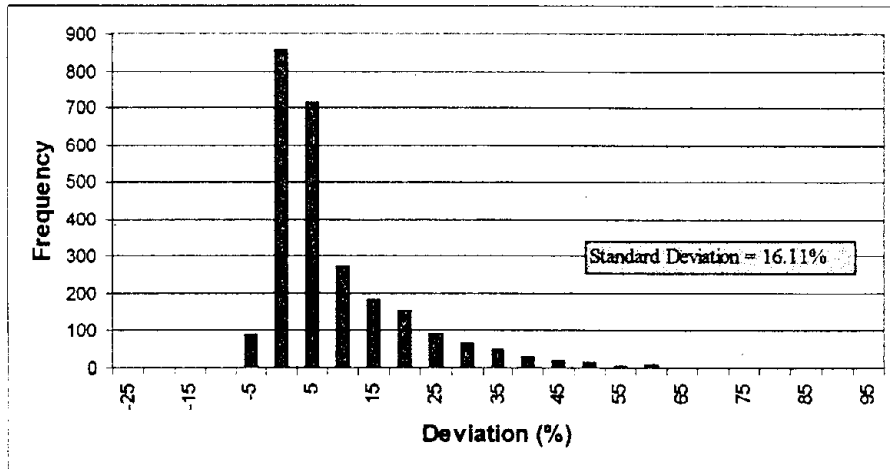
Block Diagrams of Clear Sky Composite Image

Better infrared/visible ratio - Method #3

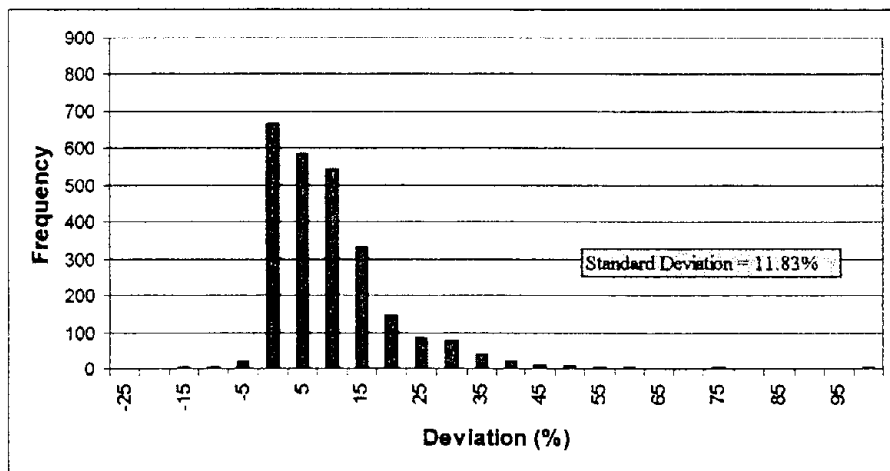


Comparative Analysis

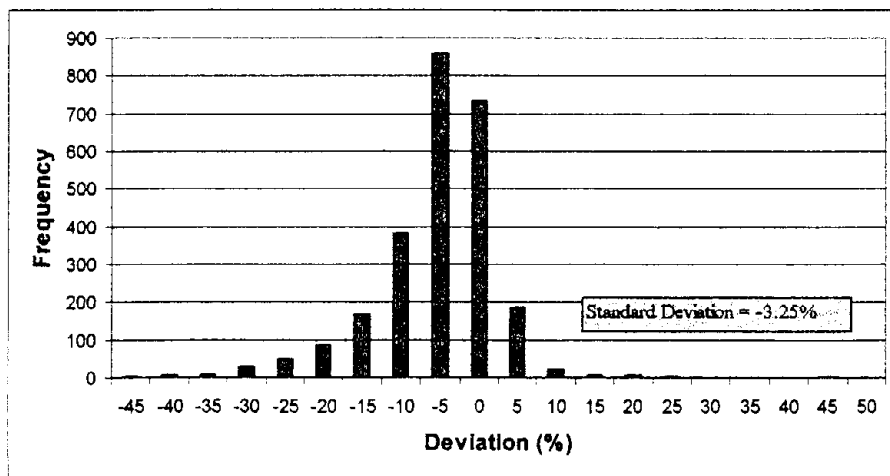
- (A) Relative deviation between Method 2 and Method 1
- (B) Relative deviation between Method 3 and Method 1
- (C) Relative deviation between Method 3 and Method 2



(A)



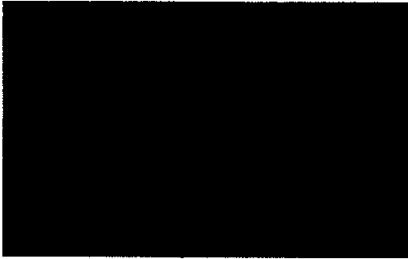
(B)



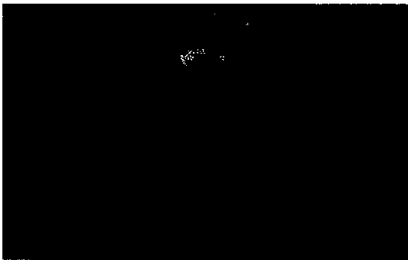
(C)

Composite Images

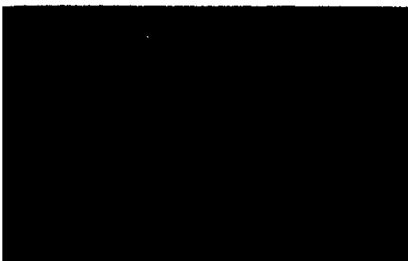
Florianópolis sector (45W to 55W and 25S to 35S)



(A) Clear Sky Image
obtained through Method 1



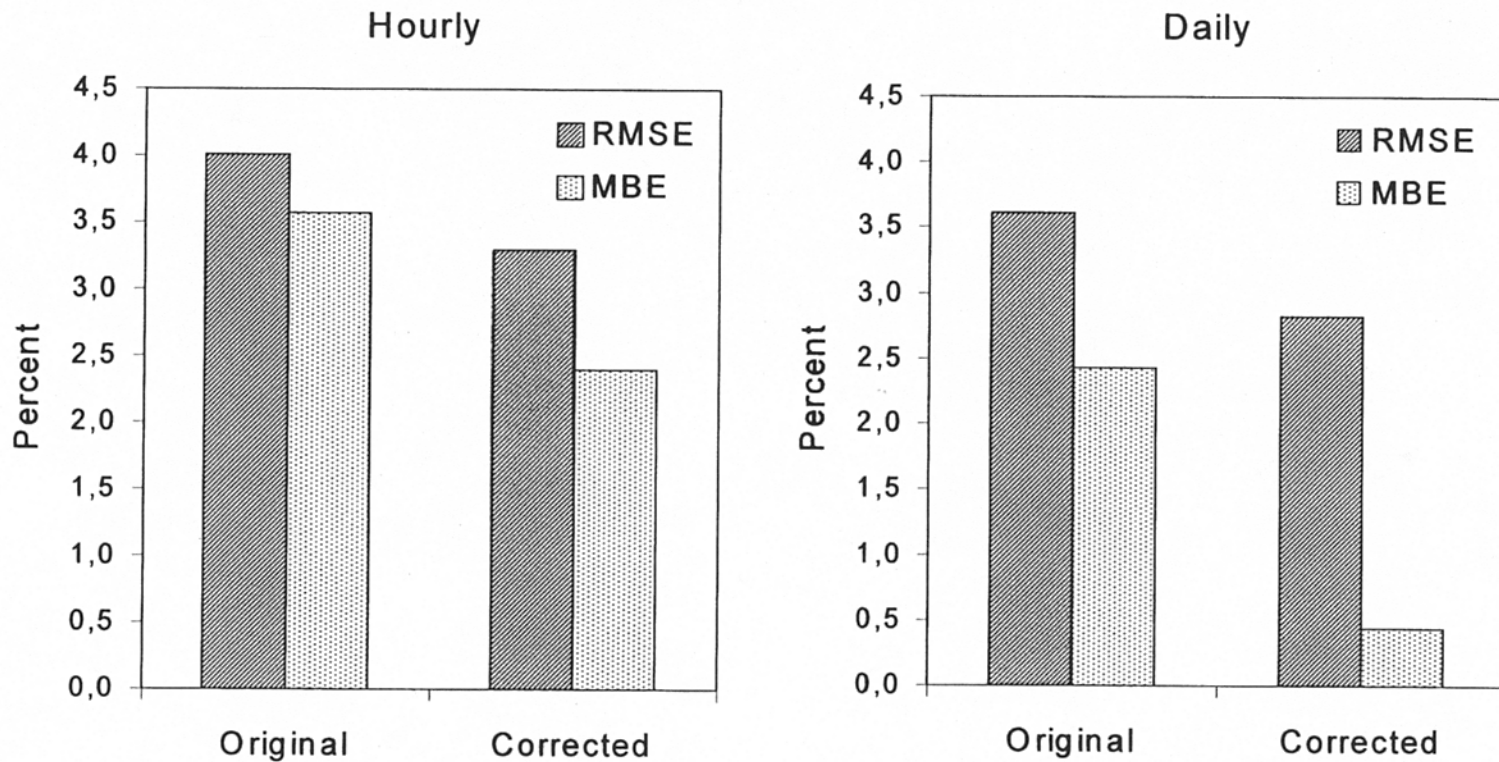
(B) Clear Sky Image
obtained through Method 2



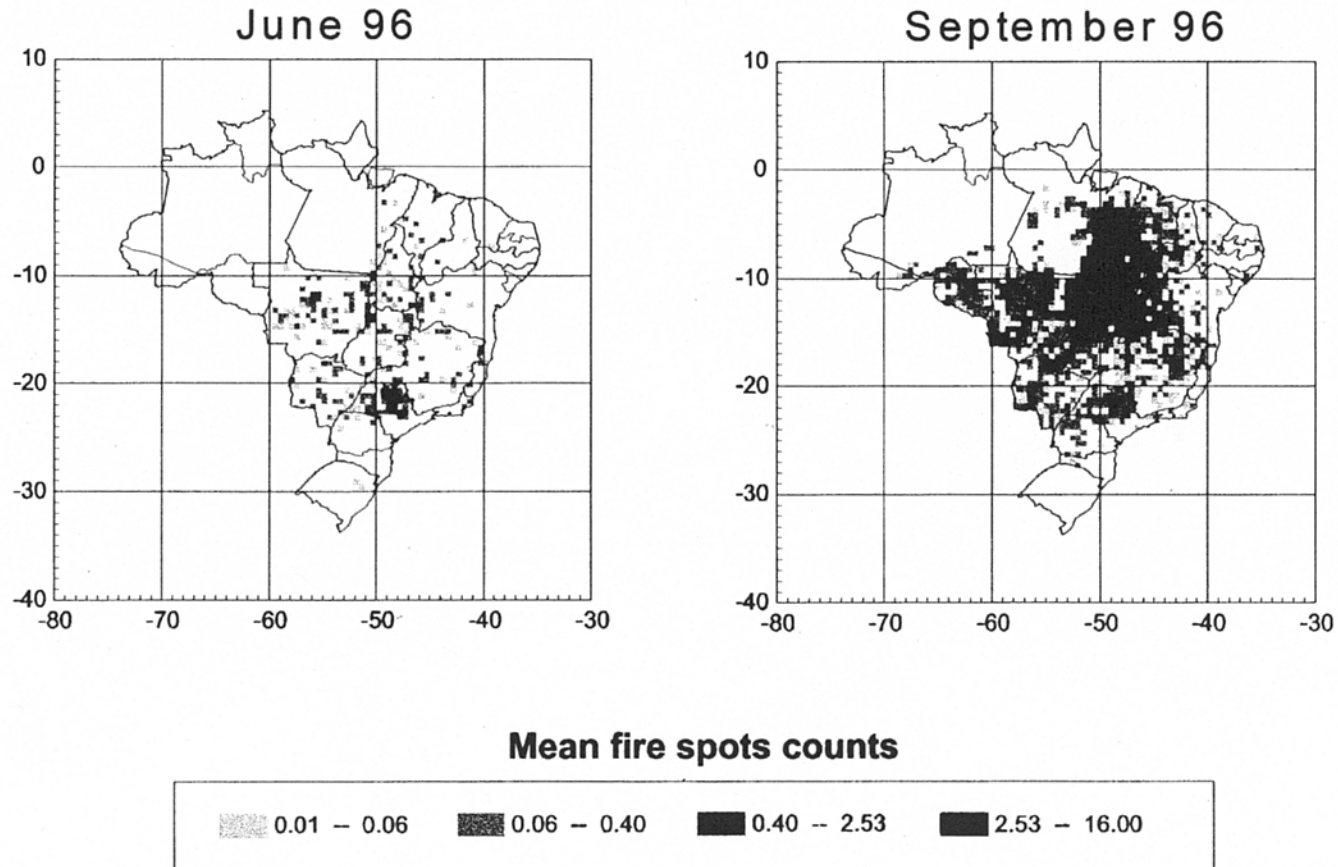
(C) Clear Sky Image
obtained through Method 3

Correction for altitude effects on model deviation

Water vapor is 50% distributed within the first 5km of the atmosphere. This affects the model estimations of solar radiation in targets located at high altitudes. Thus, it was necessary to modify the calculation of the precipitable water while keeping the relative humidity constant. This was made by reducing the vertical profile of temperature through a wet adiabatic curve between the sea level and the target level.

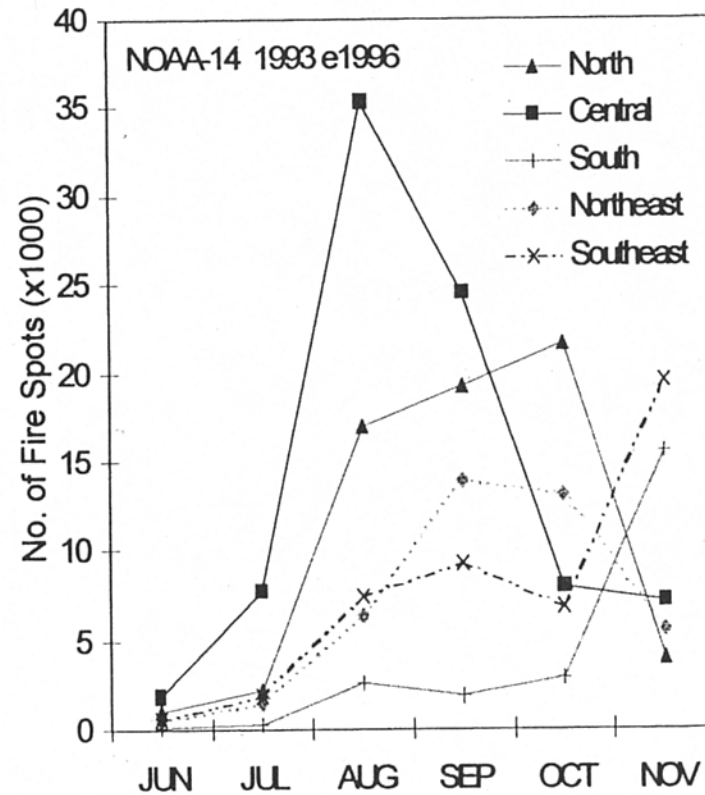


Geographical distribution of the total number of fire spots counted during the months of June and September of 1996. Data were calculated by using NOAA-12 AVHRR thermal sensor



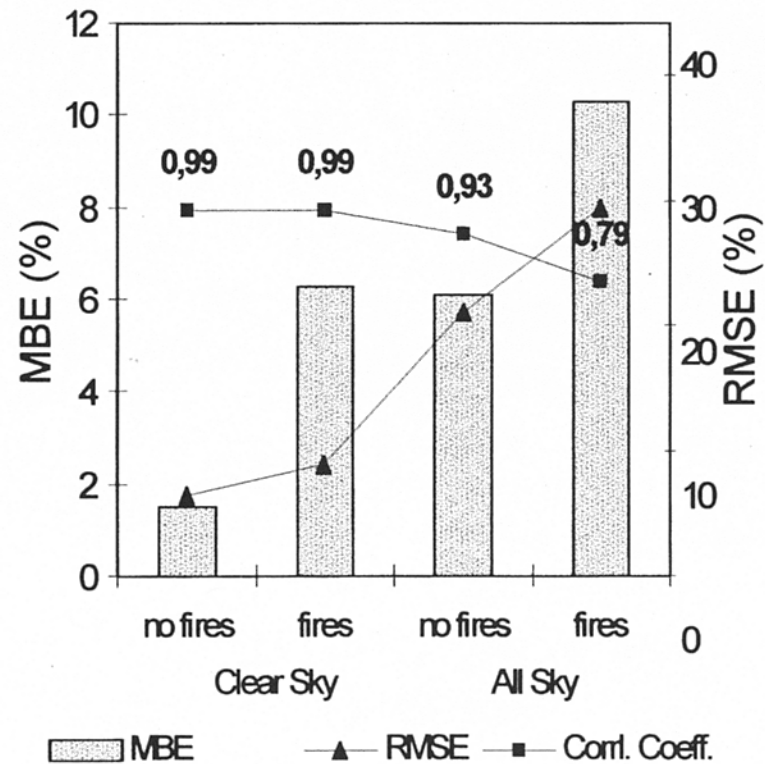
Number of fire spots in the five main climatic regions of Brazil

- Fire spots are detected by the NOAA-14 AVHRR satellite sensor at channel 3 (3.55 - 3.93 μm).
- Data are routinely acquired by CPTC-INPE and available at: www.cptec.inpe.br/products/queimadas
- Fires as small as 30m can be detected.
- Qualitative method - the number of fire spots is proportional to the area hit by fires.

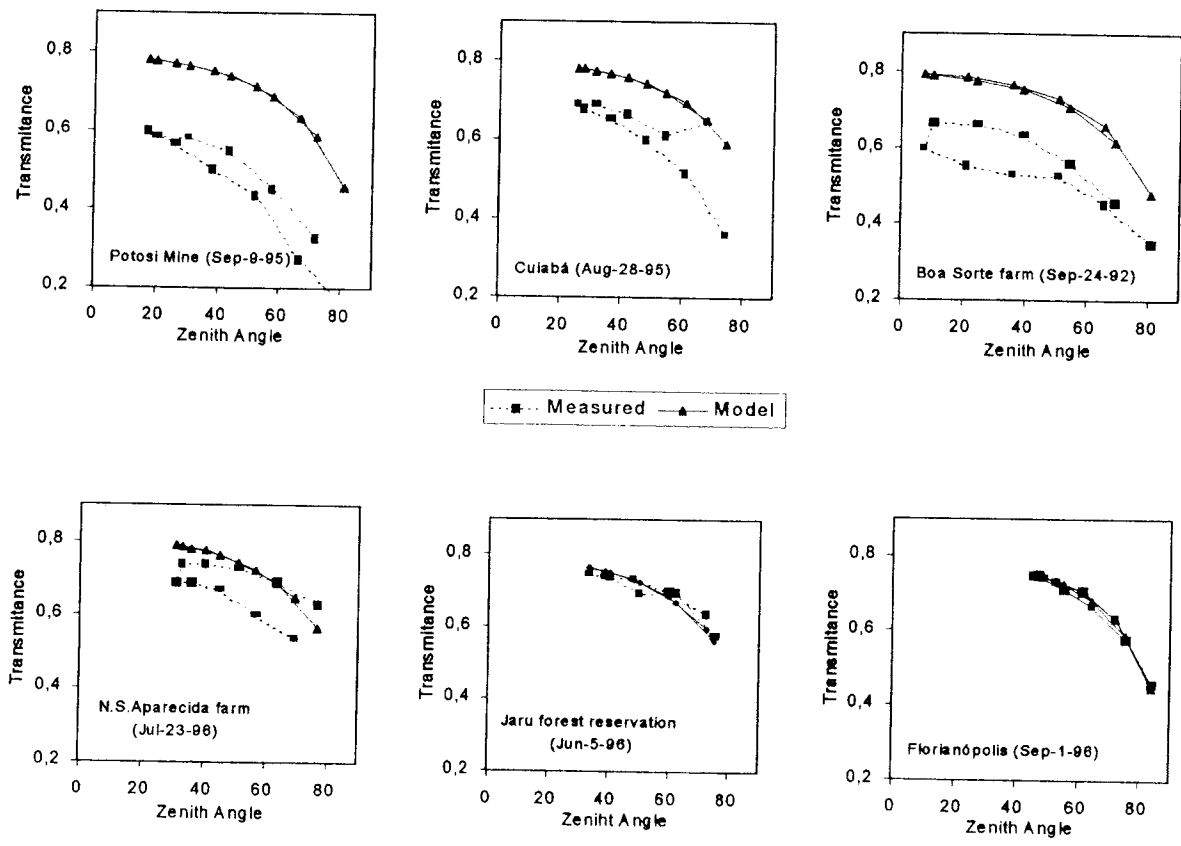


Variation of systematic errors (MBE) and random errors (RMSE) between daily sums of ground data and model estimations

- 235 clear-sky days from March trough October.
- Data split into two categories - for sites within and outside the biomass burning regions.
- Correlation Coefficients are indicated as a blue dashed line.
- Systematic deviation is about 4 times larger inside the burning region during clear sky days.

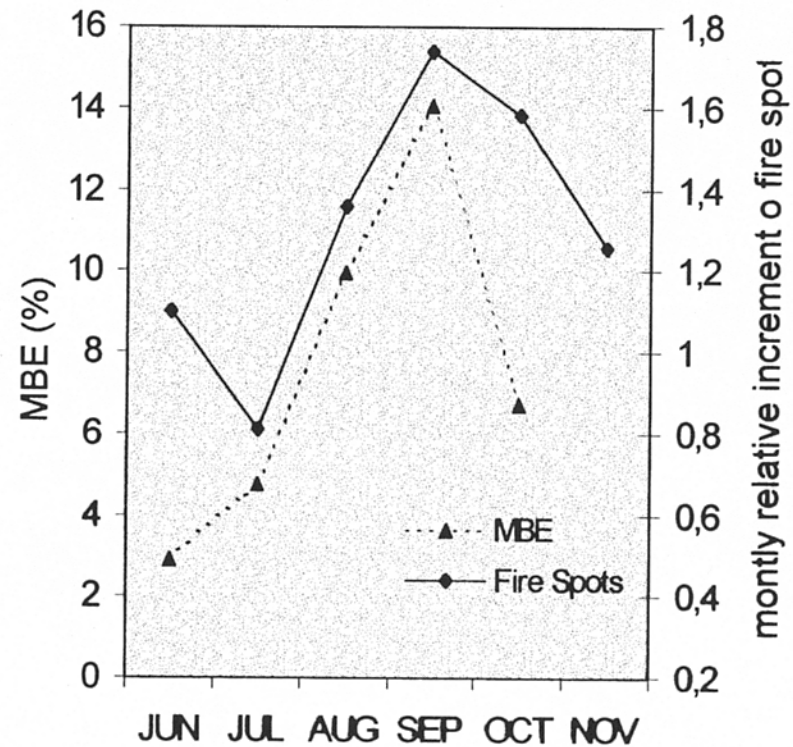


Impact of biomass fires on light transmittance versus solar zenith angle for several cases.

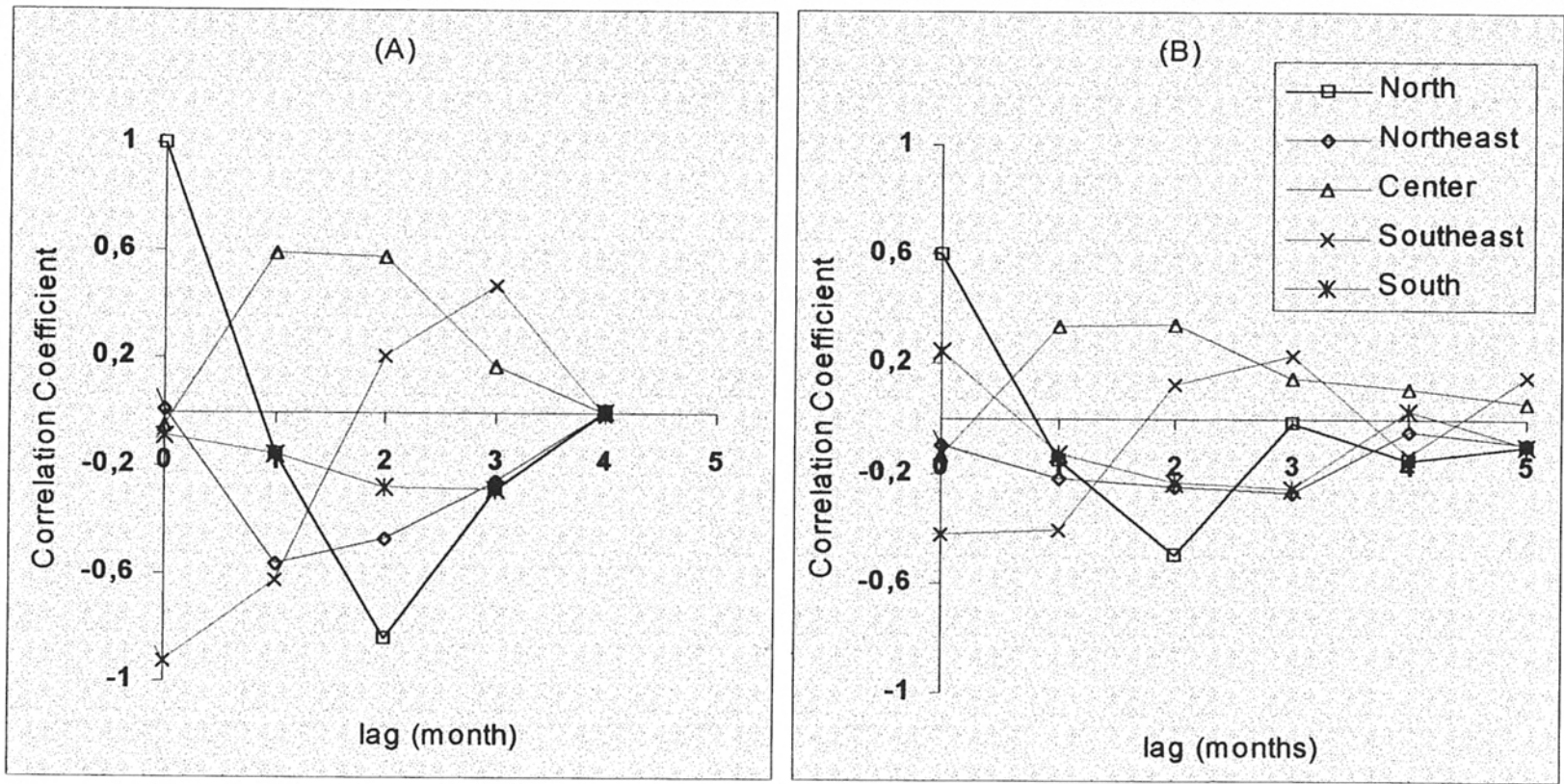


Time series for the MBE and number of fire spots in the Amazon region of Brazil.

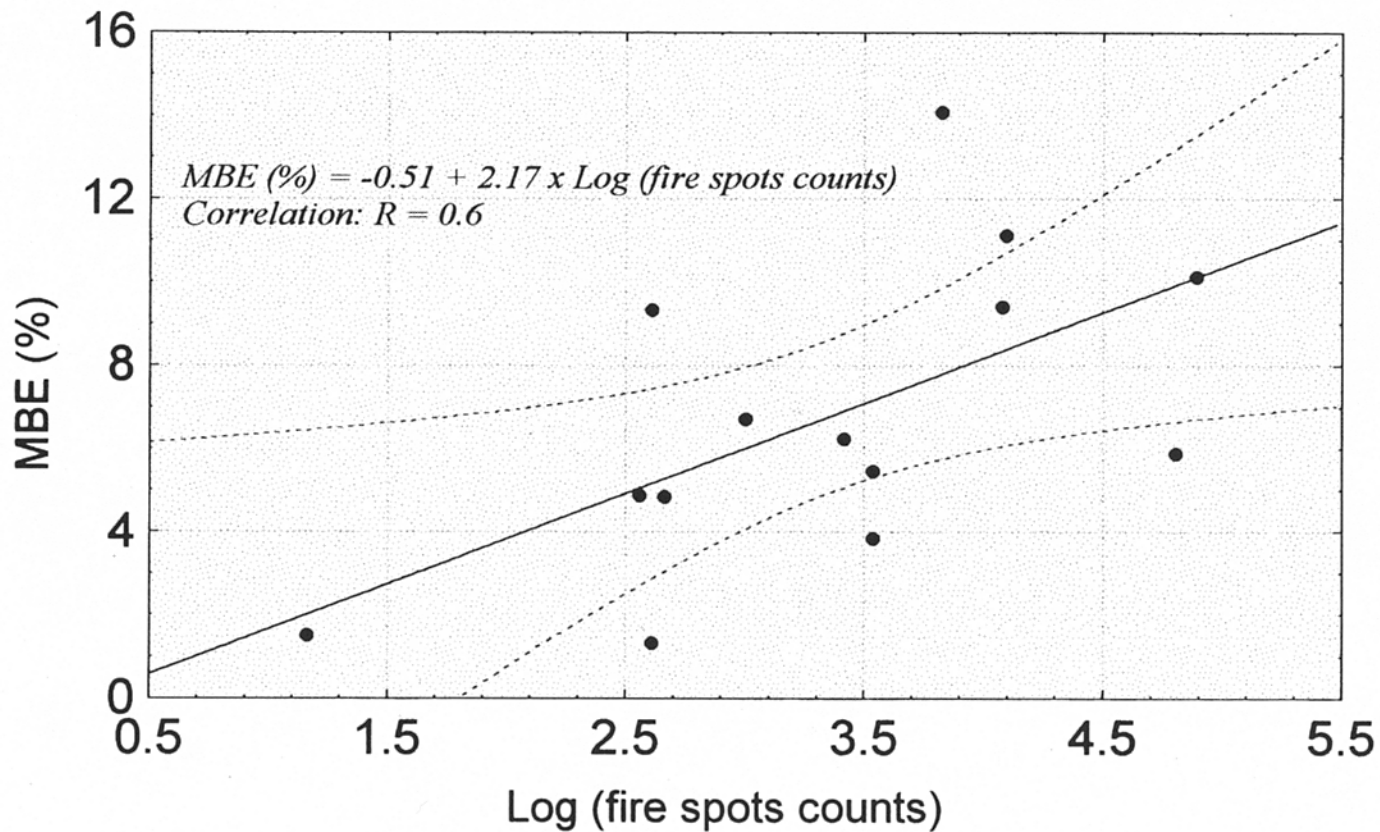
- The maximum MBE is found for September when biomass burning activity in the area is also at its maximum
- The agreement between these two curves suggests that the two variables are linked to each other



Cross correlation between time series for MBE and fire spots performed for validation sites located in the biomass burning area (A) and for a site outside this area, in Florianópolis (B).

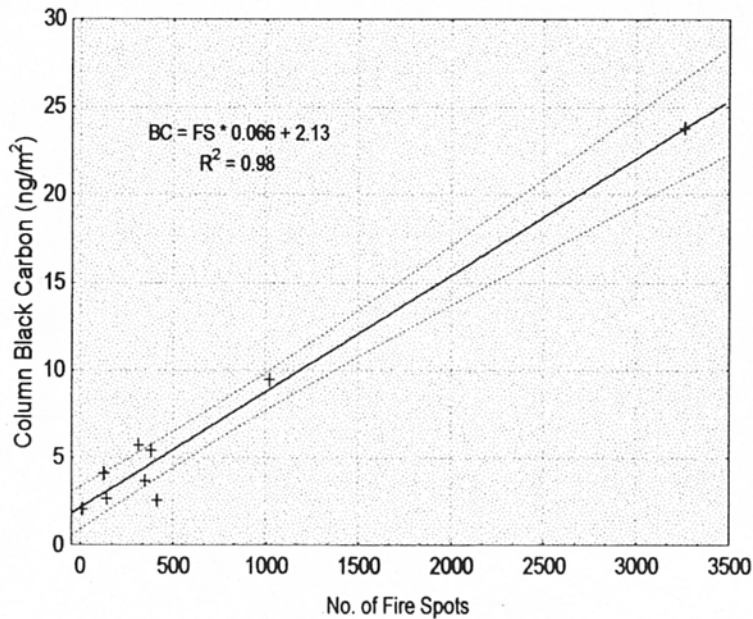


Plot of the relative mean bias error (MBE) and the logarithm of the number of fire spots counted inside a 2.5° circle of investigation around the ground solar station. The dotted line represents the 95% confidence level for the straight-line fitting



Correlation coefficients between fire products and fire spots during biomass burning season

- Column concentrations of fire products were estimated by integrating over vertical profiles of data obtained during SCAR-B field mission in the Brazil (1995);
- Fire spots were counted inside 2.5° circles of investigation centered at each column concentration data site;
- All major fire products presented positive correlation with the fire spots.

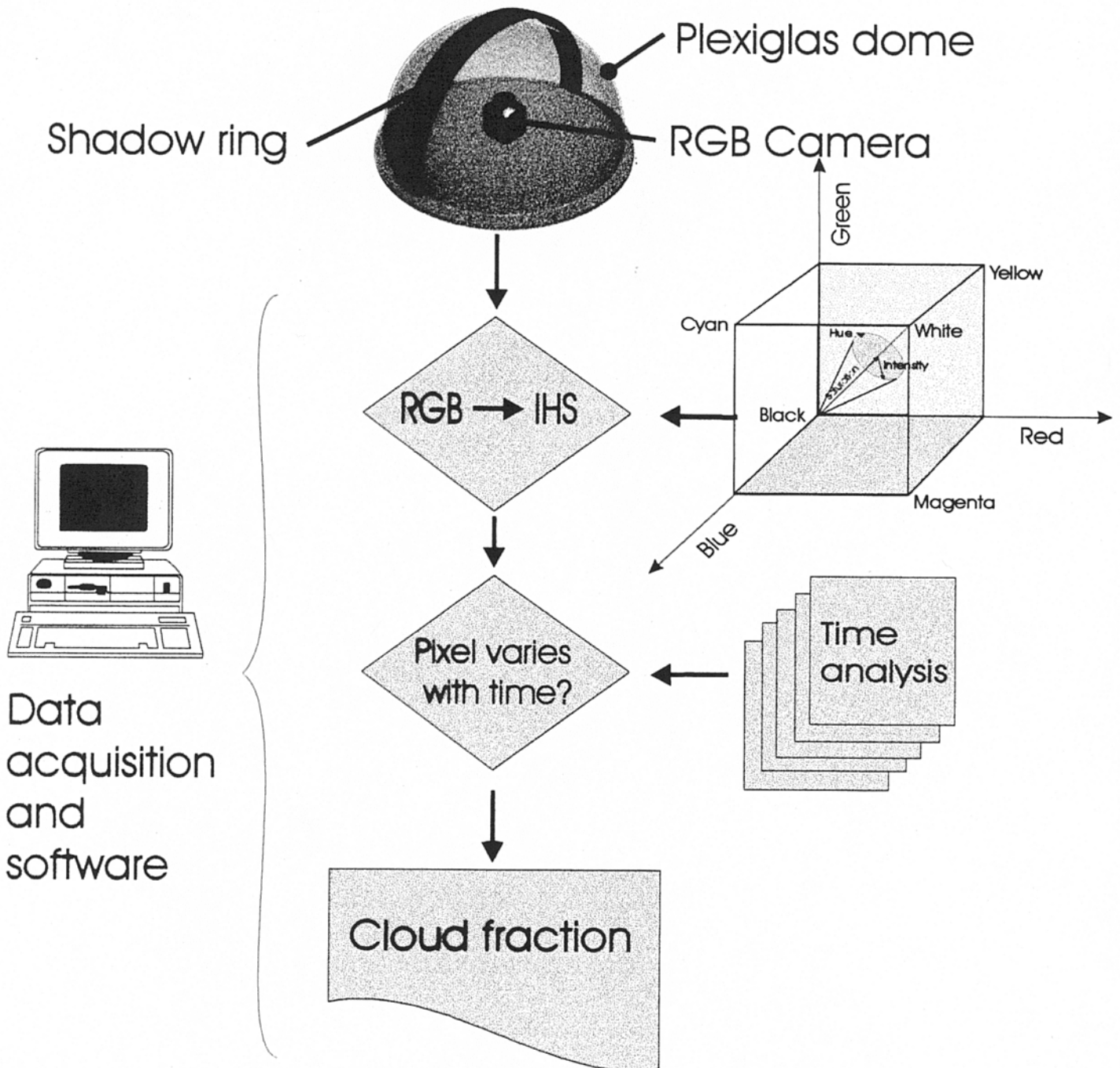


<i>Combustion Product</i>	<i>Correlation Coefficient (R²)</i>	<i>N^o of profiles</i>
Total aerosol mass	+0.98	5
Black Carbon	+0.98	9
Submicron particle count number	+0.95	5
CH ₄	+0.90	5
N ₂ O	+0.65	5
CO	+0.45	5

* the + indicates a positive correlation

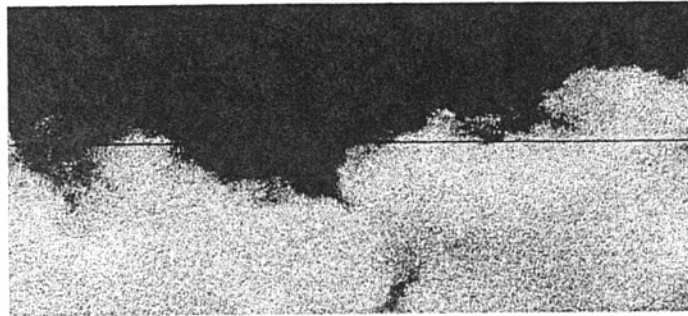
Automatic Cloud Fraction Monitor

(ground data validation for satellite models)

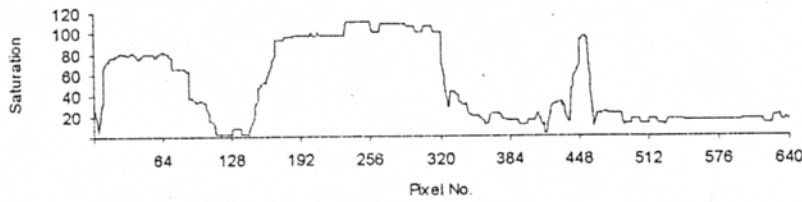


Result of Cloud Fraction Discrimination

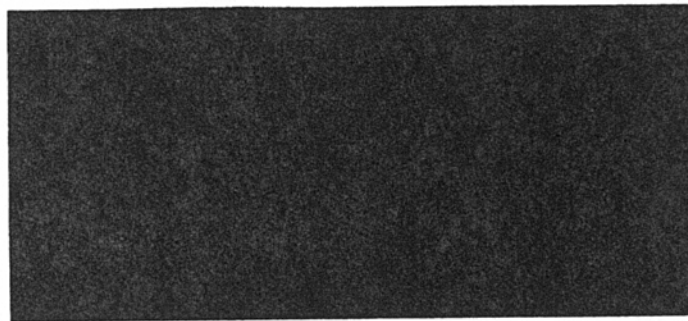
Line 152 →



Raw image from camera



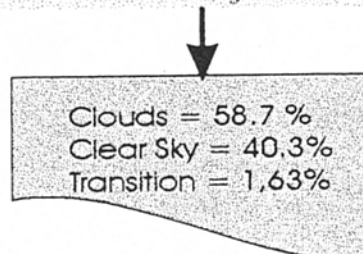
Scan of line 152



Saturation map



Cloud discrimination code



Final statistics

SOLAR RADIATION IN THE AMAZON DURING THE LBA

SUBMITTED TO THE: *Large-Scale Biosphere-Atmosphere Experiment in Amazonia*

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OBJECTIVES:

- To enhance the existing network for ground-truth of satellite derived data.
- To provide a data basis on solar radiation at ground level over Brazilian Amazonian territory for various application and scientific processes.

MILESTONES:

- Set up of four ground stations for solar radiation and basic meteorological data acquisition in distinct sites of the Amazon region.
- Provide on a routine basis qualified-compiled ground-truth radiation data for several satellite applications.
- Derive, on a routine basis, surface solar global, diffuse and photo-synthetically active radiation data using the BRAZIL-SR radiation model.
- Validate and inter-compare some existing satellite-based models for solar radiation.
- Set up of a historical data archive of visible/infrared GOES-8 satellite images for Brazil.
- Measure and compile aerosol concentration profiles data in the Amazon troposphere.
- Study of the effects of burning of biomass on the radiation measurements and estimations

Ground Solar Radiation Sites

- Set-up three Solar radiation stations for global and diffuse radiation, and basic ground meteorological measurements – air temperature, wind speed, pressure, (UFSC-INPE-BMBF/Germany)
- Locations are: The Hydro-electrical power plant of Coaracy Nunes (Macapá)
São Gabriel da Cachoeira (Northeast of the Amazonas)
Hydro-electrical power plant of Samuel (Southeast of Roraima)
- Existing BSRN site at Balbina (UFSC - WMO/BSRN)

Provide Ground Radiation Data for Various Applications

- Radiation data from these four radiation measurement sites will be provided on a routine basis qualified ground radiation data (global and diffuse short-wave)
- Data will be acquired via telephone modem at a 2-minute sampling interval from our ground radiation reference station in Florianópolis, SC
- Qualification, storage and distribution of ground radiation data will be made by LABSOLAR

Derive Surface Radiation Data by Radiation Model

- The BRAZIL-SR radiation model will be employed on a routine basis to derive surface radiation data for SW-global, SW-diffuse, and photosynthetically active radiation.
- Model radiation data will be generated and distributed by INPE

Radiation Model Validation

- Several radiation model validation will be performed during LBA by using the ground data provided by this project and also by using the infra-structure available by other LBA projects
- A study on ground data interpolation versus satellite predictions will be a by-product of this work
- By now, four radiation model groups agreed to participate in this validation experiment: the INPE/UFSC/GKSS (Enio, Colle, etc.), the SUNY (Perez and colab.), The Albany (Pinker and colab.) and the NREL (Renee crew) groups.

Parameterization of the Aerosol in Model Predictions

- The strong influence of aerosols from burning of the biomass during the dry season will be studied in order to implement radiation models to take this effect into account
- This will be made by using sunphotometric data (both existing, and to be implemented by this project), and also field measurements in airborne missions

Ground Stations

