

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

Presentations

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



Presentations

Products and Projects in South America

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The talk will cover a review about products developed in the past 20 years with emphasis on the currently available products derived either from ground station data or satellite images. Monthly means of incoming global radiation derived from satellite is compared with the estimates derived from the Angström method, as published by OLADE Organización Latinoamericana de Energía.

An illustrative analysis is presented to show that the uncertainty of the monthly means of global radiation data available for South

America is too large, for the purpose of feasibility analysis of photovoltaic plants.

A brief report concerning the projects underway in South America is also presented. Very few countries have devoted significant effort in research to assess solar radiation data, in spite of the fact solar energy market is growing.

Special effort should be addressed to bring together the national capabilities in order to undertake a project to assess solar radiation over South America.

PRODUCTS FOR SOLAR ENERGY USERS

1. Solar radiation atlas of OLADE - Organización Latinoamericana de Energía

The distribution of global irradiation is derived from data collected from meteorological ground stations of all South American countries. These data were measured by pyranometers (P) and sunshine duration recorders (SDR) or actinographs. The global and direct irradiation are estimated by the empirical equations of Angström. A single equation is fitted for all South America. The period of measurements and the type of instruments used is given in Table 1. The quality of the data as well as the traceability of the radiometers are not reported. The data is presented graphically and numerically for the station locations.

Table 1

COUNTRY	Max Years	P	H	U	TOTAL
Argentina	22	37	96	106	239
Bolivia	7	17	25	0	42
Brazil	18	17	336	0	353
Chile	24	59	1	0	60
Columbia	9	0	90	0	90
Ecuador	25	0	63	47	110
El Salvador	24	13	8	0	21
Falkland Islands	3	1	0	0	1
Guyana	8	0	15	1	16
Paraguay	9	0	16	0	16
Peru	3	5	61	0	66
Surinam	5	0	19	0	19
Uruguay	5	5	0	0	5
Venezuela	29	29	63	0	92

Max Years: Maximum number of years of data.

P: Irradiance measured using pyranometer.

H: Data calculated from cloud cover information or bright sunshine hours.

U: Data from source lacking information on instrumentation.

2. Atlas of Solar Radiation of Brazil

Edited by the University of Pernambuco, Recife

Authors: Prof. Naum Fraidenreich and Shiguero Tiba

The work reports data obtained from Angström technique derived from ground truth collected by actinographs and pyranometers installed in the meteorological stations of INMET - Brazilian Weather Service. The accuracy of the estimated data is not carried out. Data is presented in graphical form obtained by linear interpolation from station locations.

3. Atlas of Global Solar Irradiation in Brazil - 1st Version Derived from Satellites

Edited by INMET - Brazilian Weather Service, November 1998

Authors: Prof. S. Colle and Dr. E. B. Pereira

The data is presented in graphical images as well as in multimedia form. The description of the physical model used to compute the incoming global radiation on the surface as well as the validation procedure and results are reported by E. B. Pereira in the present workshop. The numerical data for three hour, daily and monthly basis for spatial resolution of 0,5° x 0,5° is available in optical disk archives at LABSOLAR. The comparison between the present version and OLADE version was carried out over Brazilian territory. The OLADE data is interpolated from data of station locations by the kriging technique before the comparison is made. The relative deviation for each pixel is obtained by the following equation:

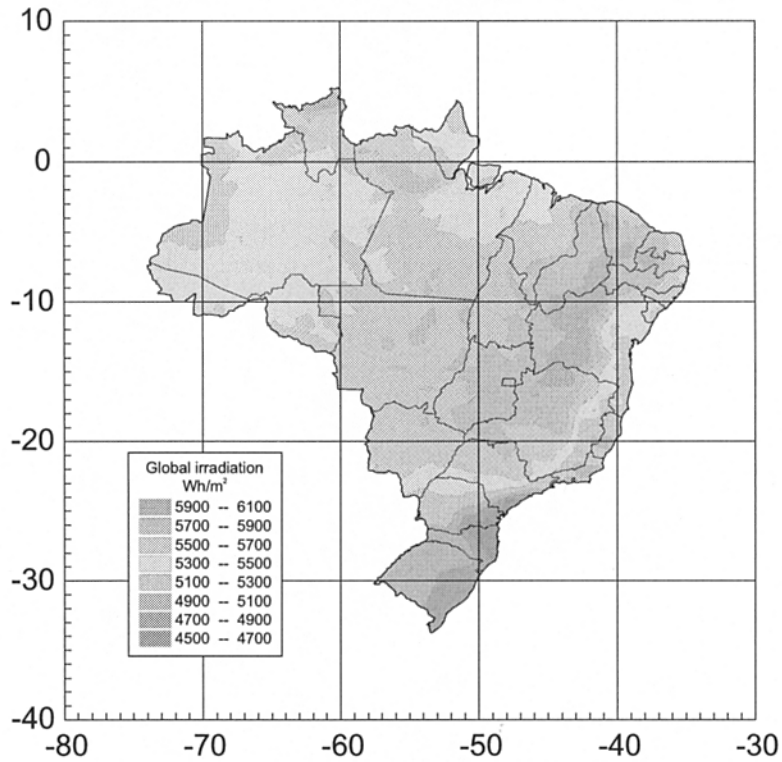
$$D(\%) = (R_{\text{SAT}} - R_{\text{OLADE}}) \times 100 / R_{\text{SAT}}$$

where R is the irradiation in Wh/m².

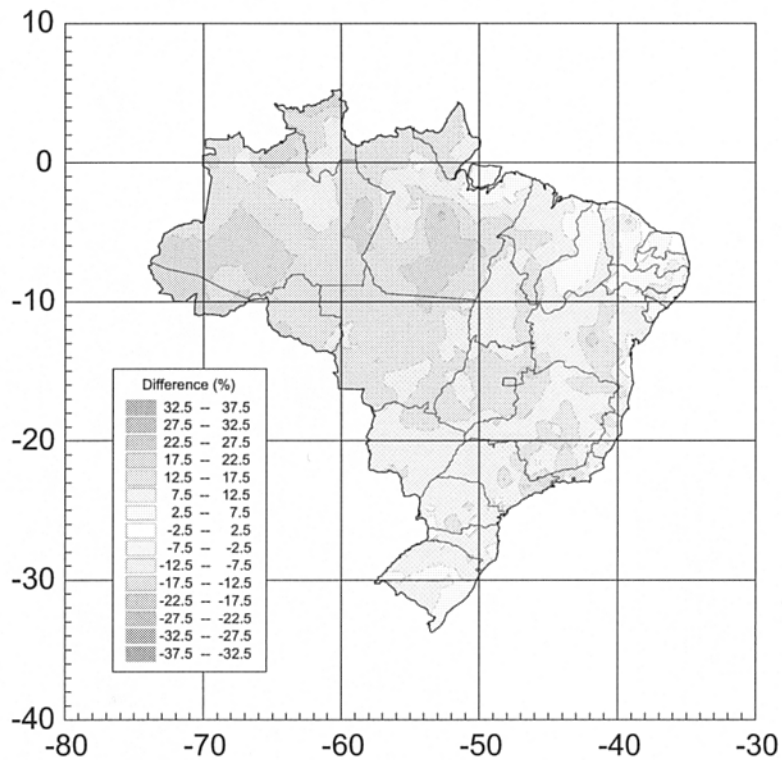
The best agreement between OLADE and satellite versions is verified for the winter season. The greatest deviations are observed in the Amazon region and Southern regions. Smaller deviations are observed in the Northeastern region. MBE and RMSE are shown in Table 2. The next figures shows the graphical images of deviations as well as the corresponding frequency histograms, for the yearly and monthly basis.

Table 2

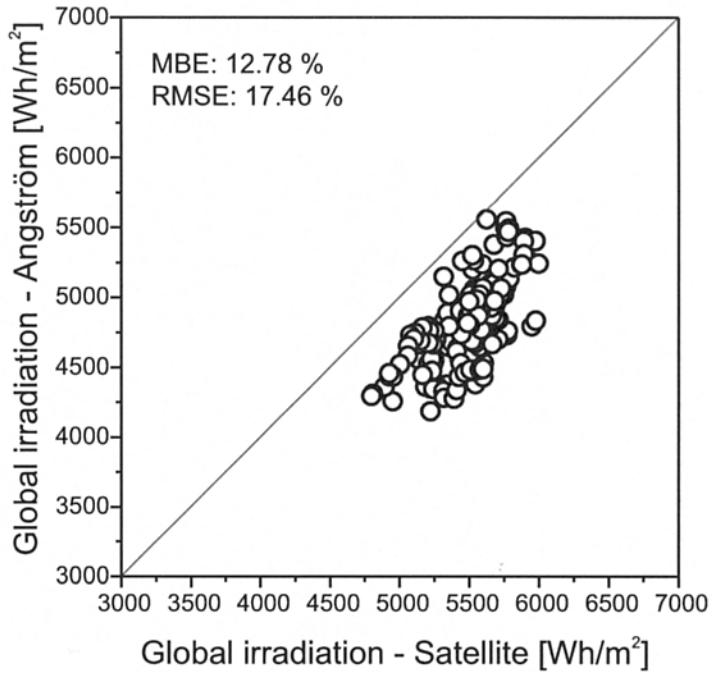
Period	MBE	RMSE
Yearly	12,78	17,46
Jan	19,54	26,26
Feb	20,30	27,26
Mar	14,17	19,32
Apr	16,27	23,08
May	5,66	11,68
Jun	9,06	14,93
Jul	-2,35	12,86
Aug	5,07	12,04
Sep	15,72	22,91
Oct	13,53	20,63
Nov	13,71	20,48
Dec	16,40	22,71



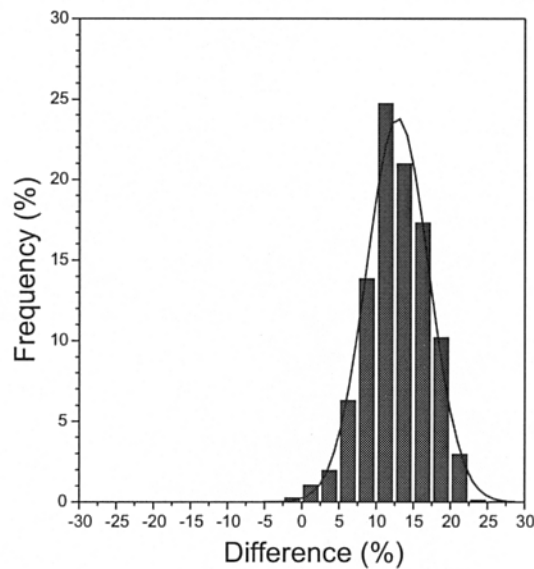
Annual mean derived from satellite data - GOES 8



Difference between satellite derived data and OLADE data (%)

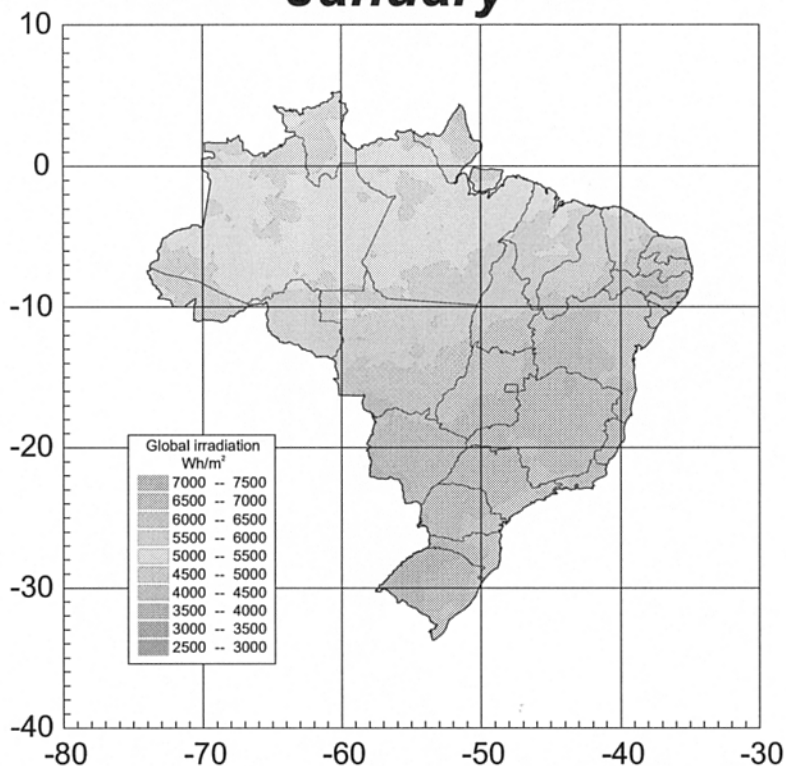


Comparison between satellite derived data and OLADE data

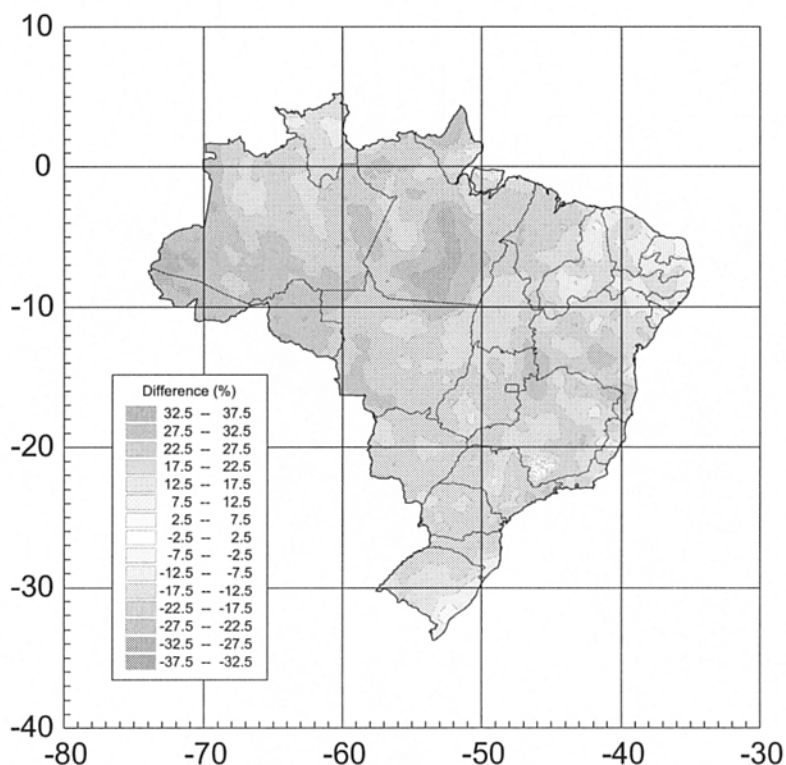


Difference between satellite derived data and OLADE data (%)

January

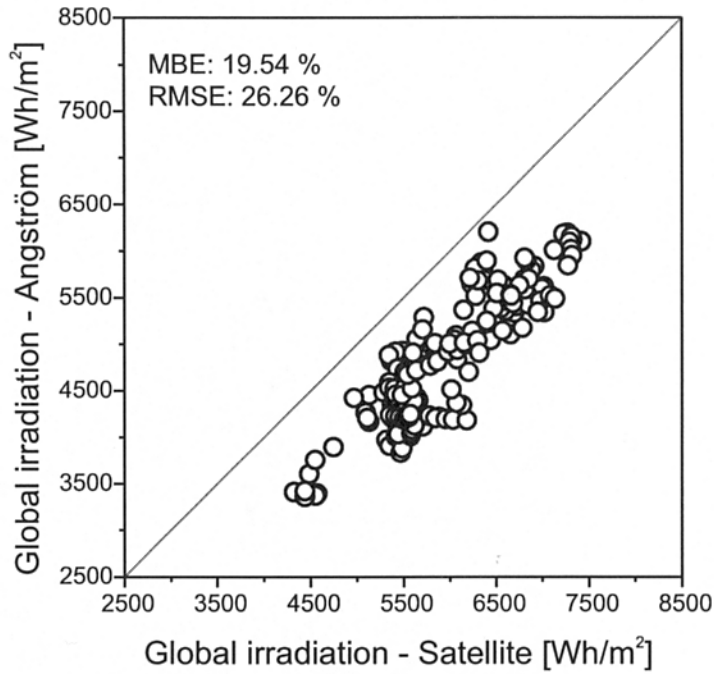


Monthly mean derived from satellite data - GOES 8

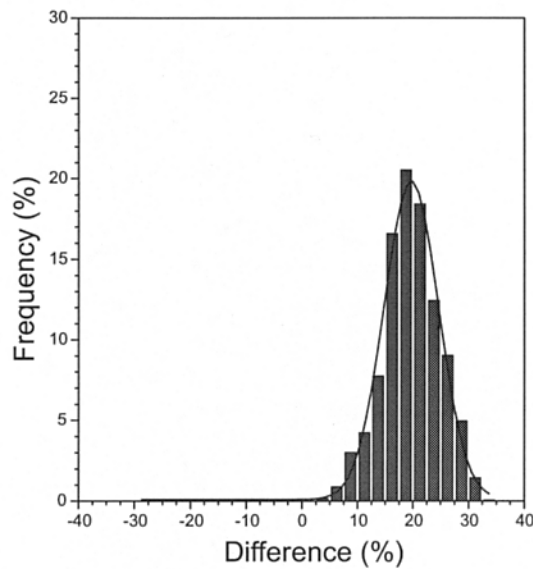


Difference between satellite derived data and OLADE data (%)

January

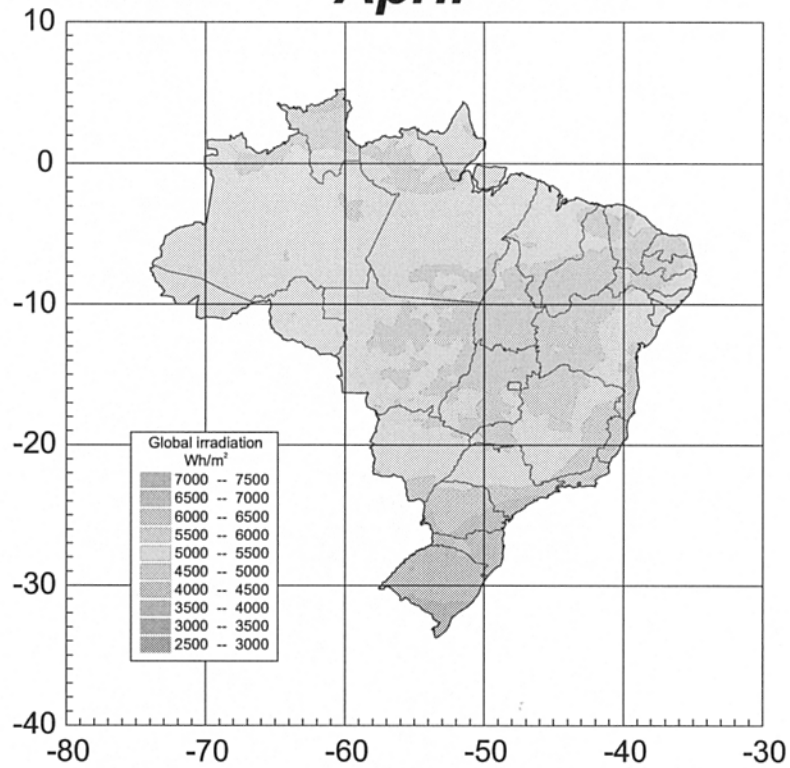


Comparison between satellite derived data and OLADE data

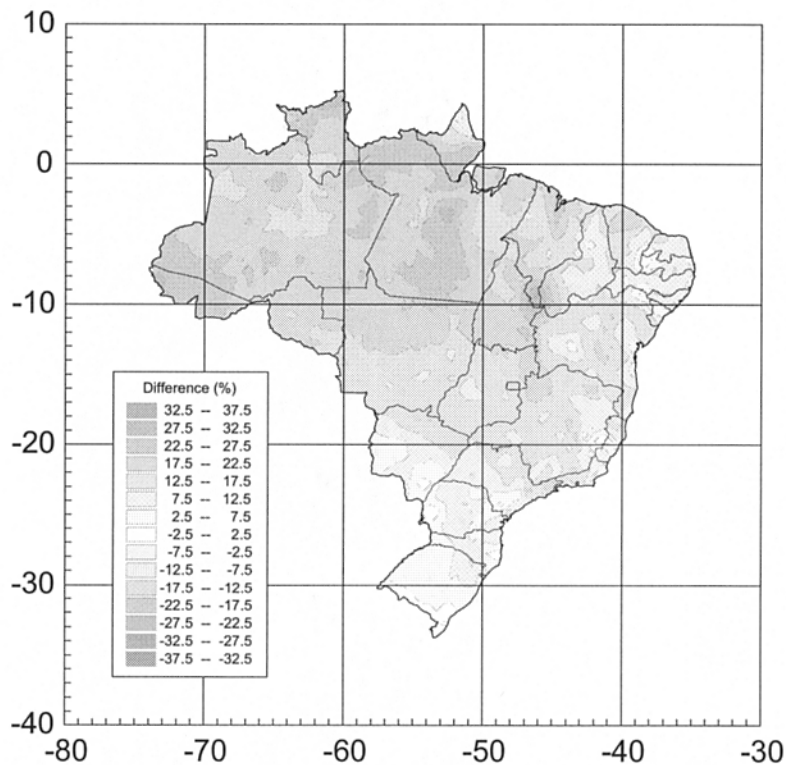


Difference between satellite derived data and OLADE data (%)

April

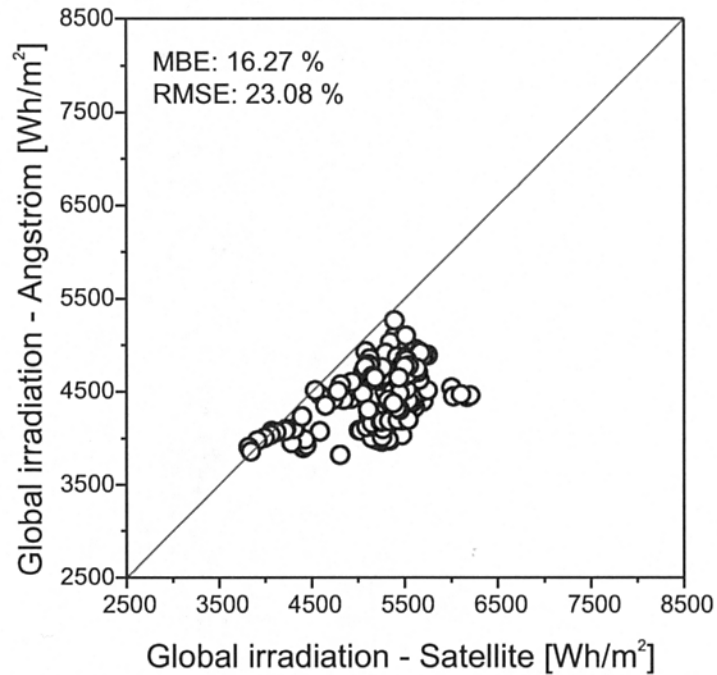


Monthly mean derived from satellite data - GOES 8

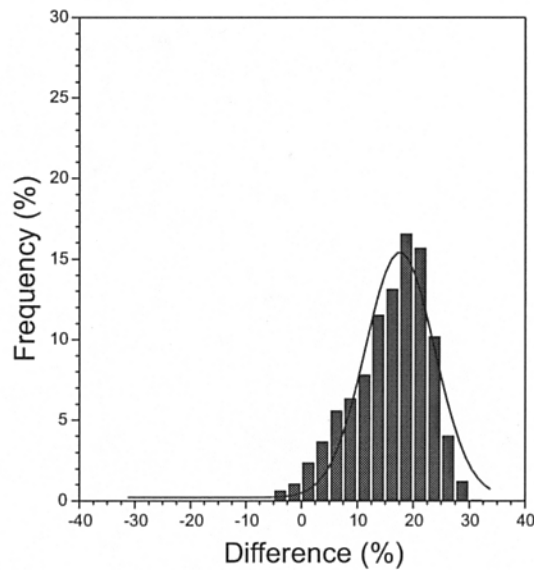


Difference between satellite derived data and OLADE data (%)

April

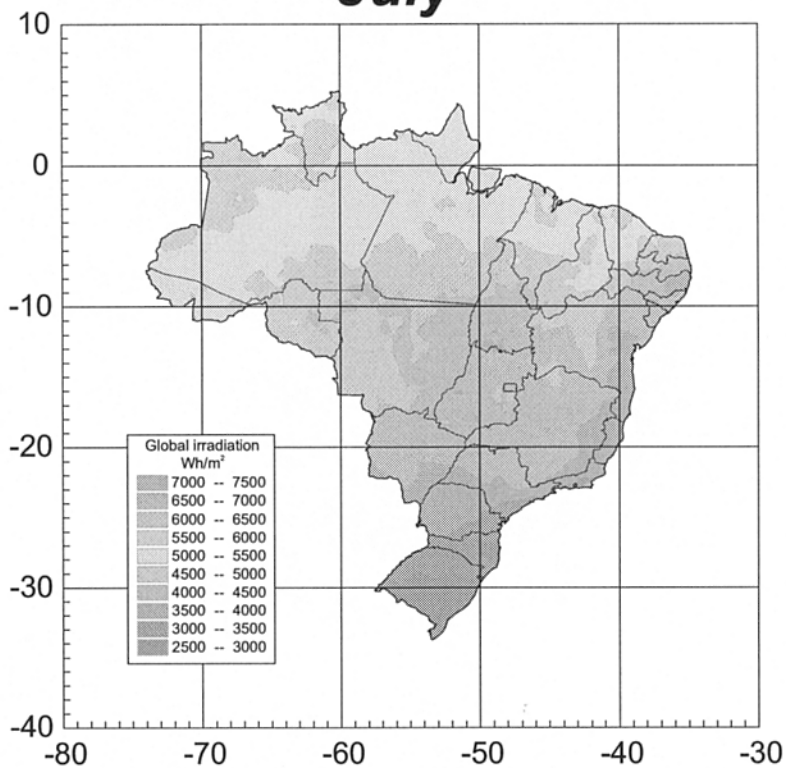


Comparison between satellite derived data and OLADE data

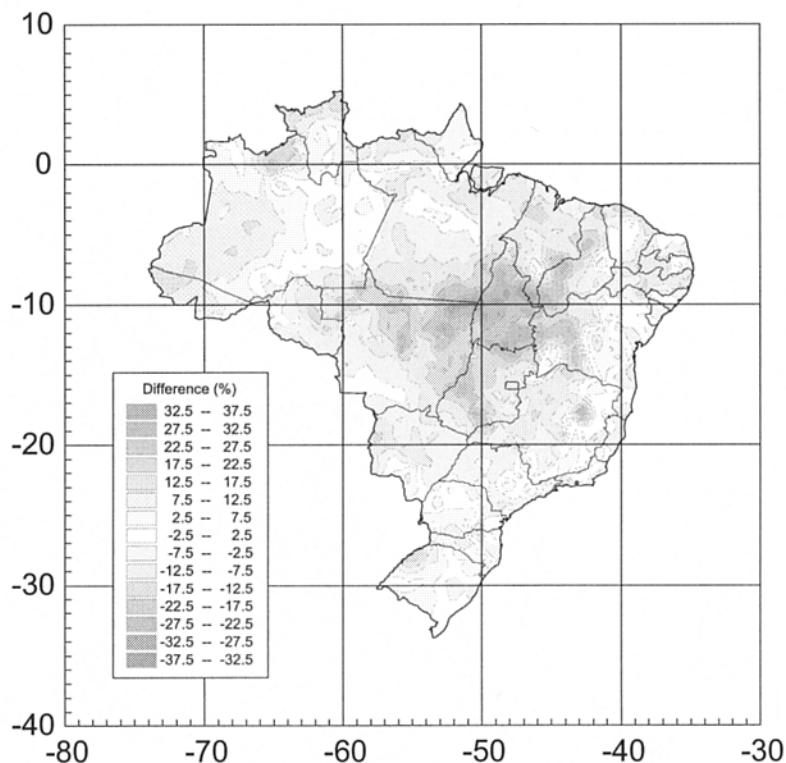


Difference between satellite derived data and OLADE data (%)

July

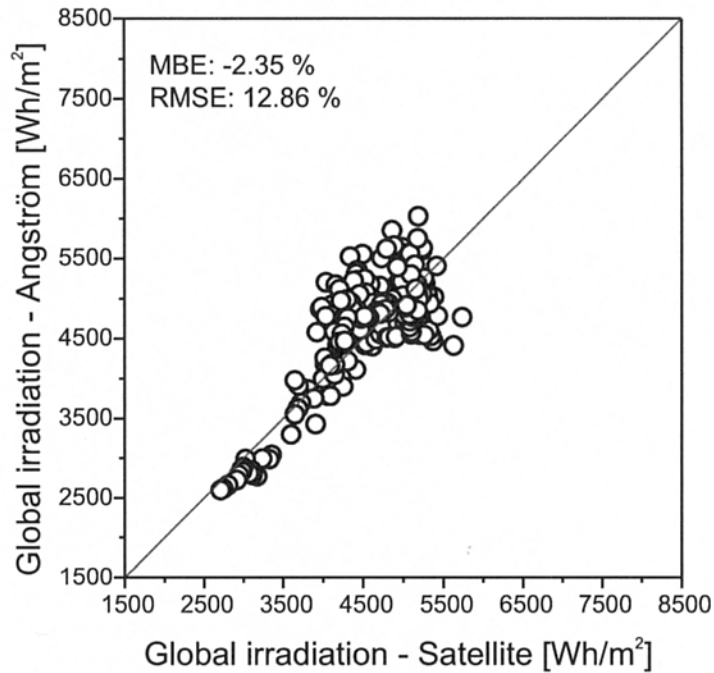


Monthly mean derived from satellite data - GOES 8

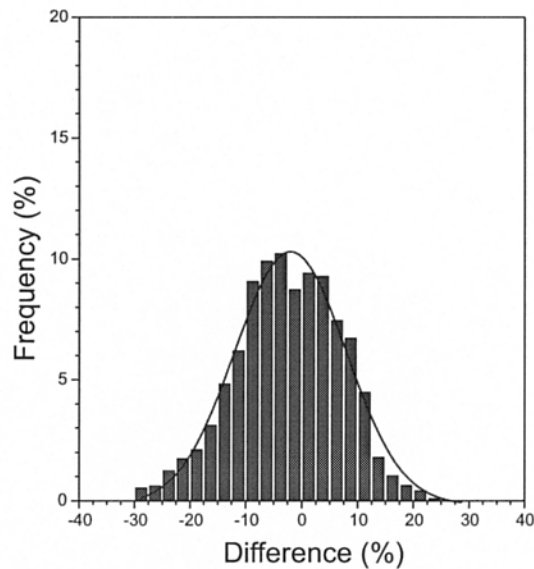


Difference between satellite derived data and OLADE data (%)

July

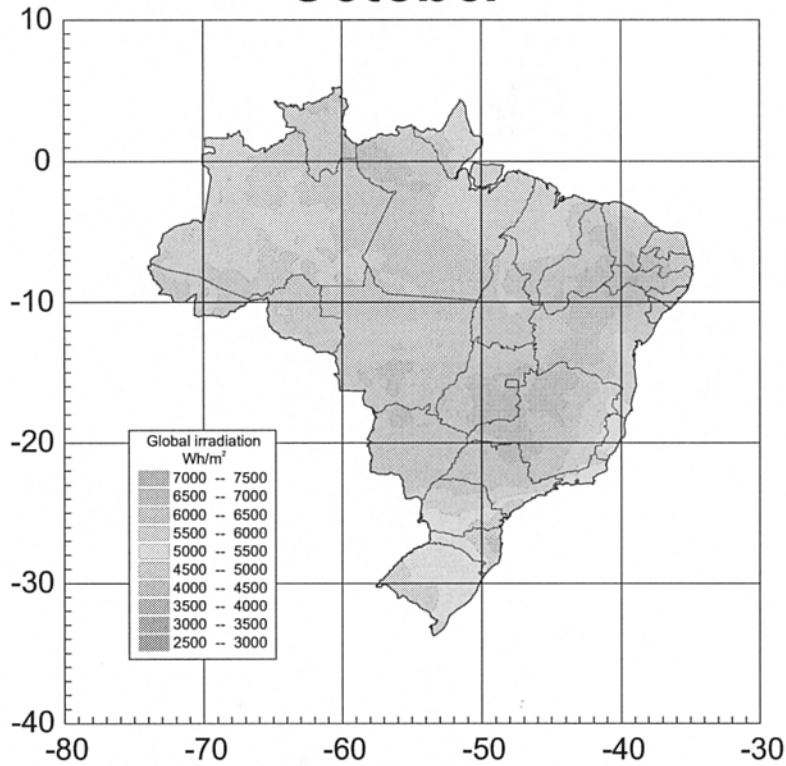


Comparison between satellite derived data and OLADE data

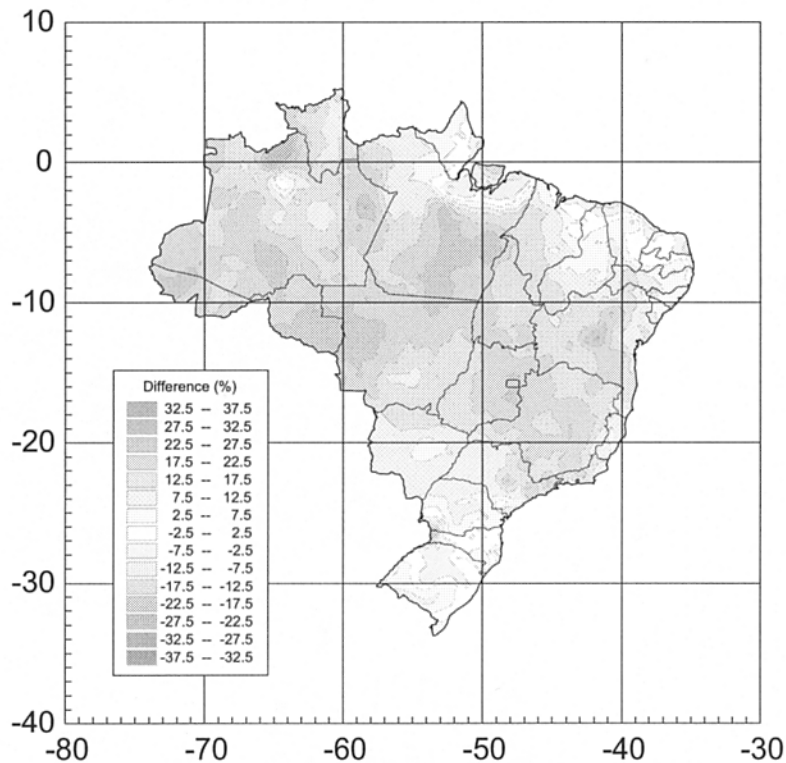


Difference between satellite derived data and OLADE data (%)

October

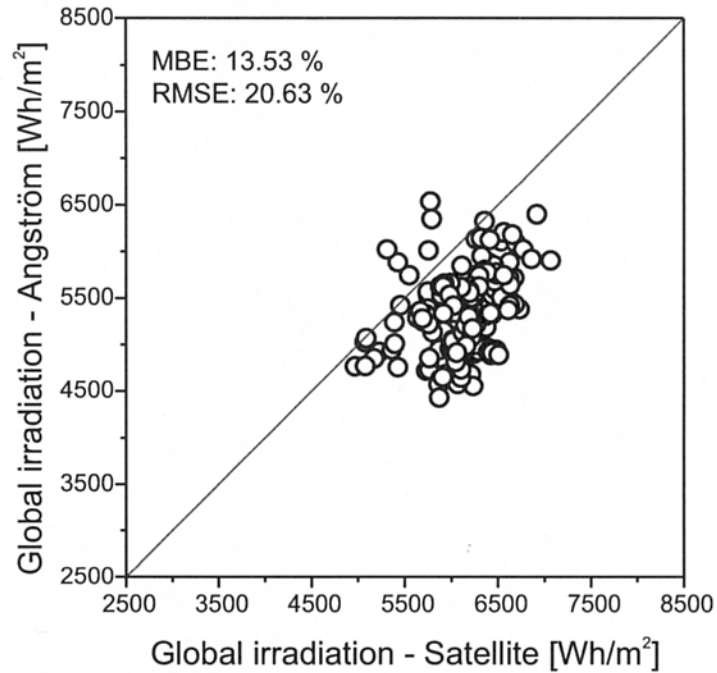


Monthly mean derived from satellite data - GOES 8

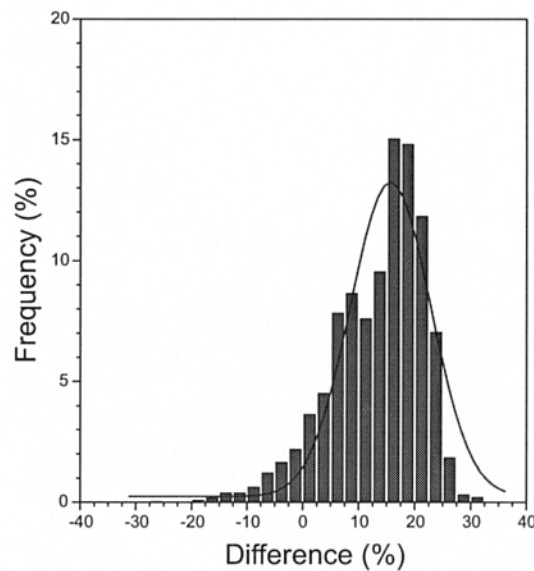


Difference between satellite derived data and OLADE data (%)

October



Comparison between satellite derived data and OLADE data

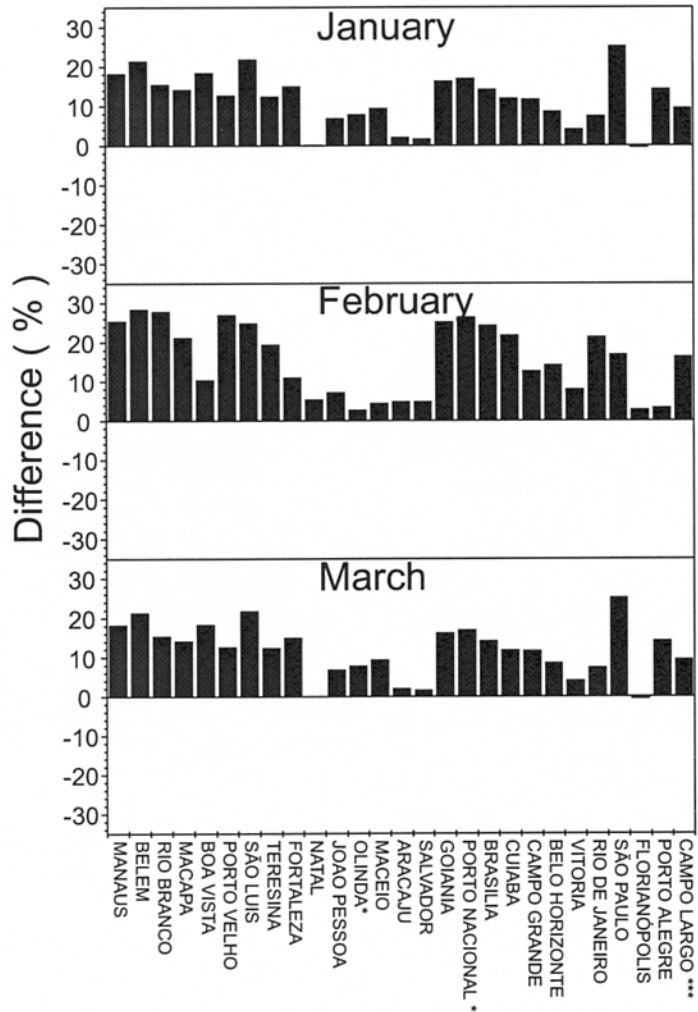


Difference between satellite derived data and OLADE data (%)

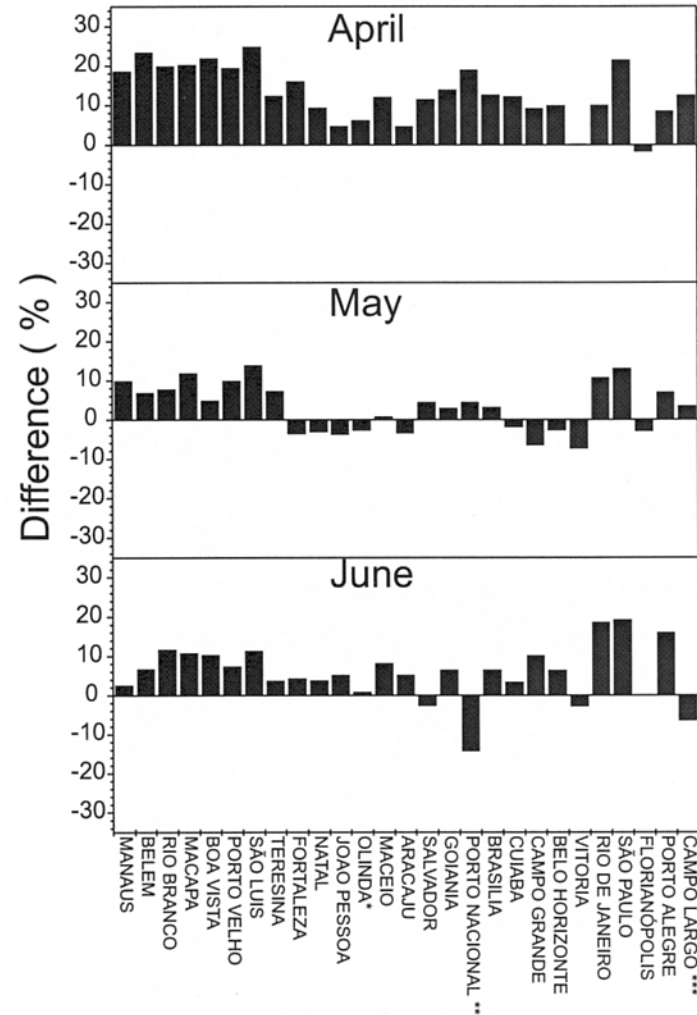
Brazilian Sites



SITE COMPARISON



Difference between satellite derived data and OLADE data (%)



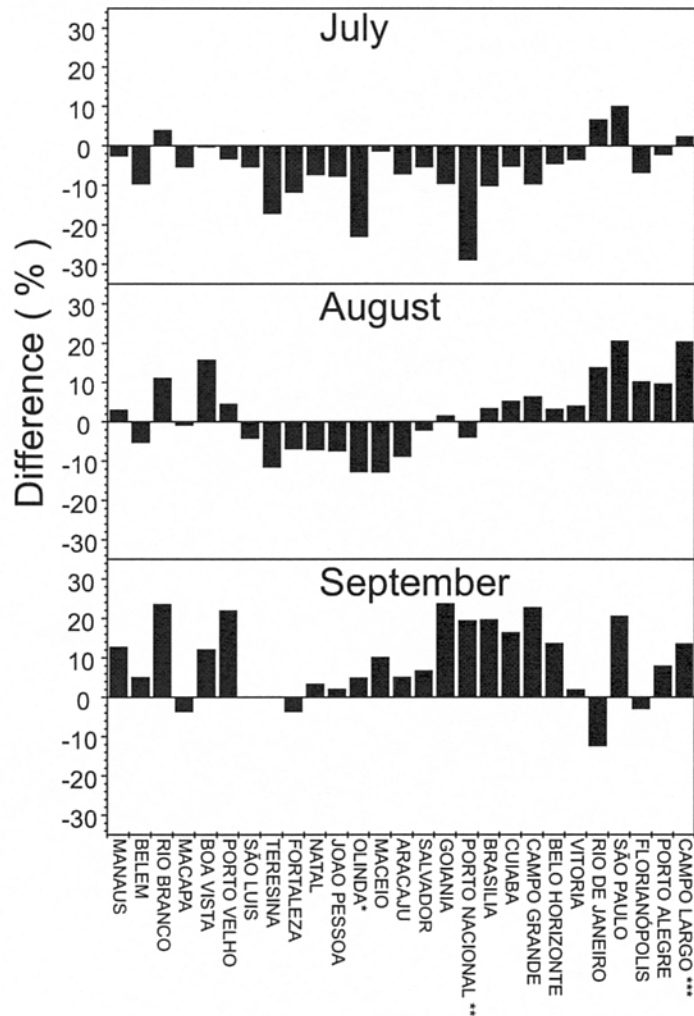
Difference between satellite derived data and OLADE data (%)

* Nearest site to Recife (PE)

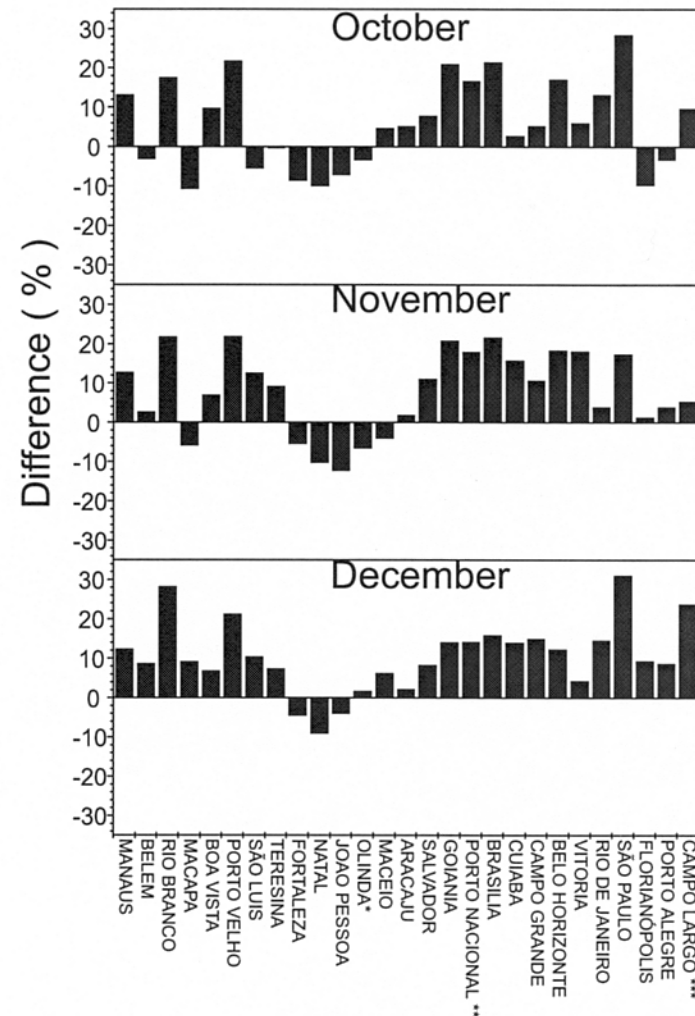
** Nearest site to Palmas (TO)

*** Nearest site to Curitiba (PR)

SITE COMPARISON



Difference between satellite derived data and OLADE data (%)



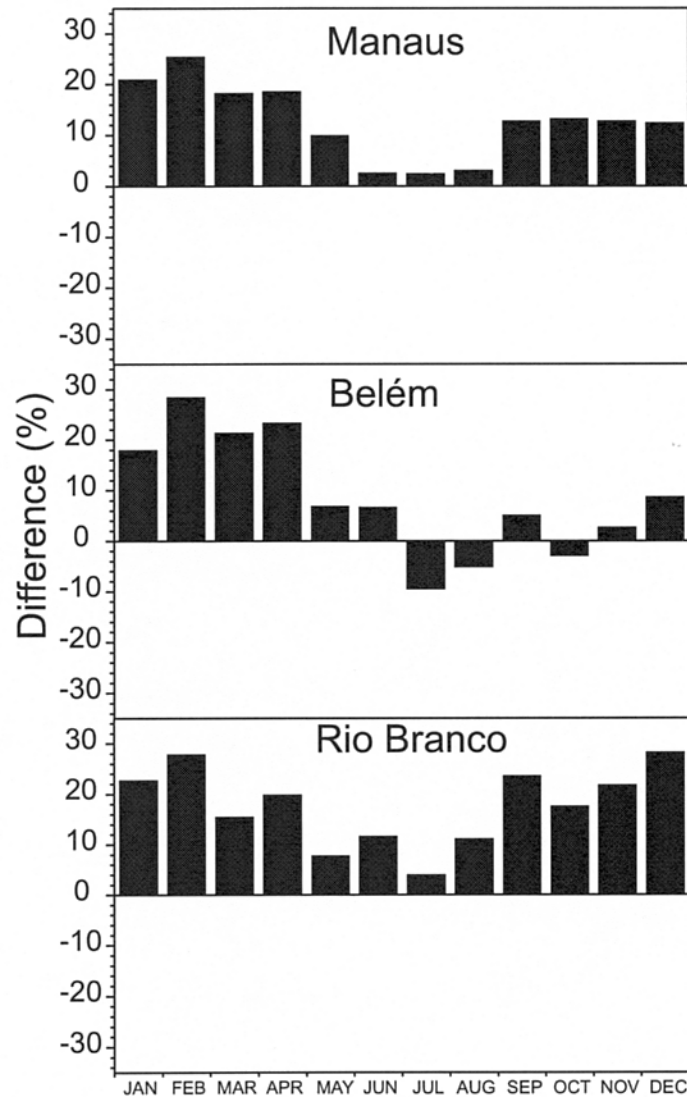
Difference between satellite derived data and OLADE data (%)

* Nearest site to Recife (PE)

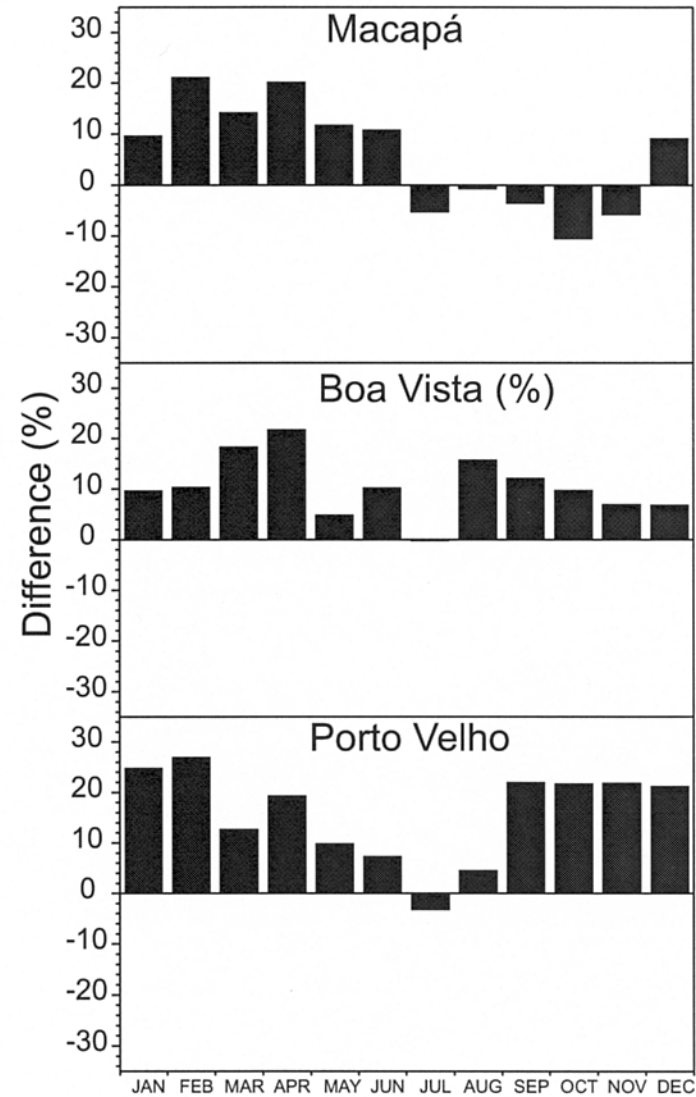
** Nearest site to Palmas (TO)

*** Nearest site to Curitiba (PR)

MONTHLY COMPARISON

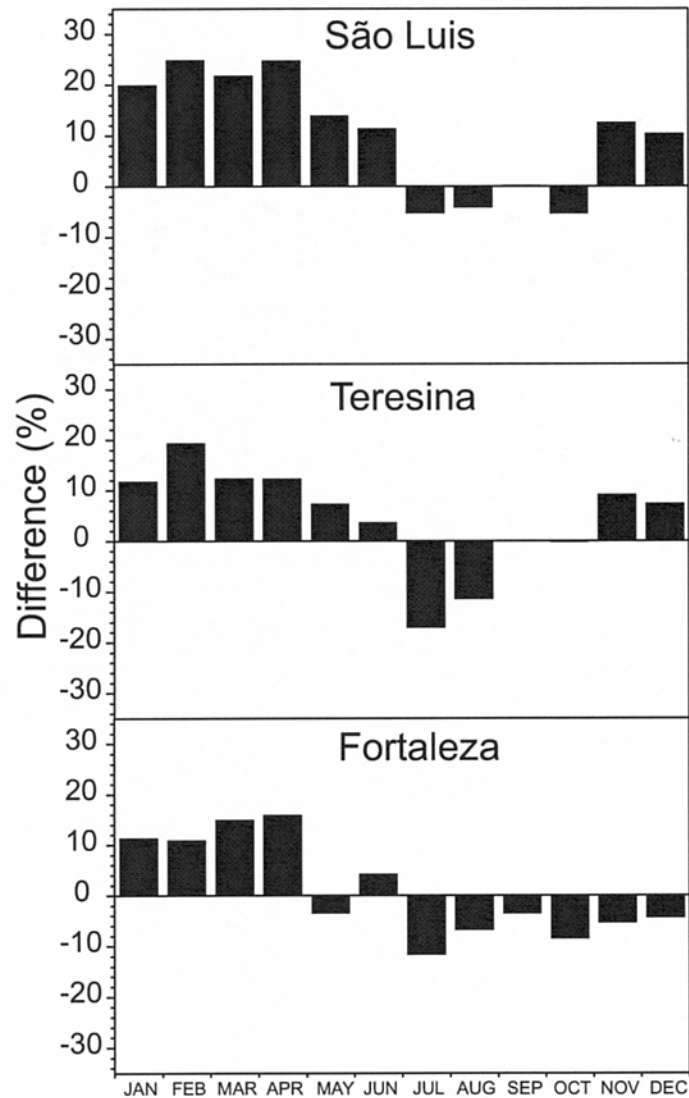


Monthly difference for Brazilian capitals (%)

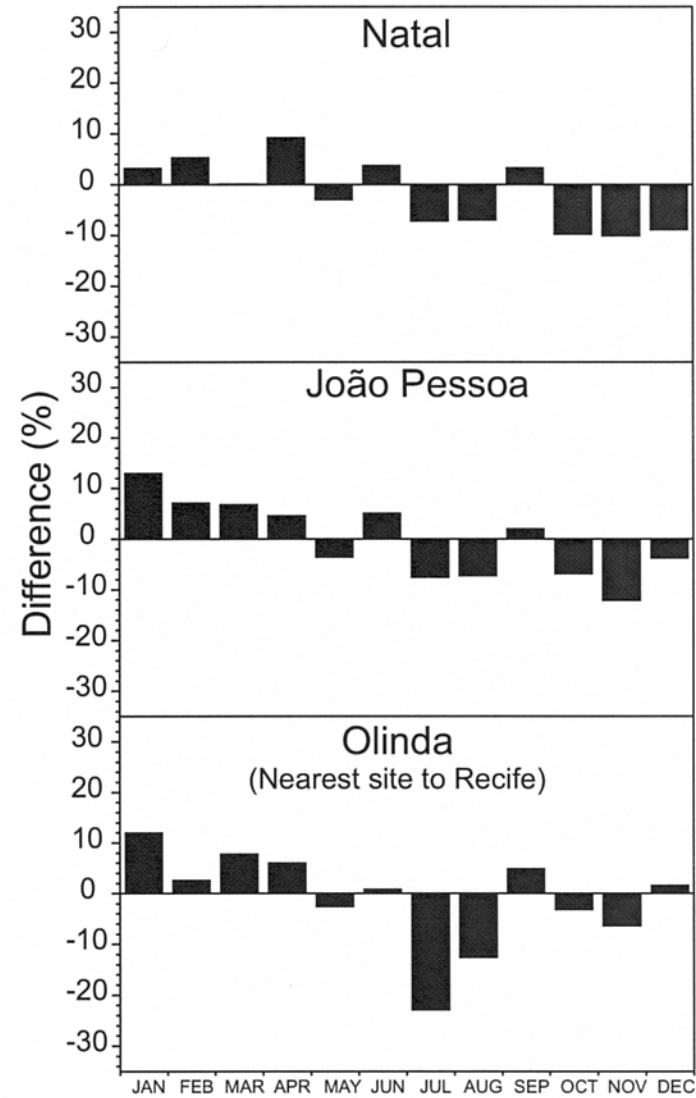


Monthly difference for Brazilian capitals (%)

MONTHLY COMPARISON

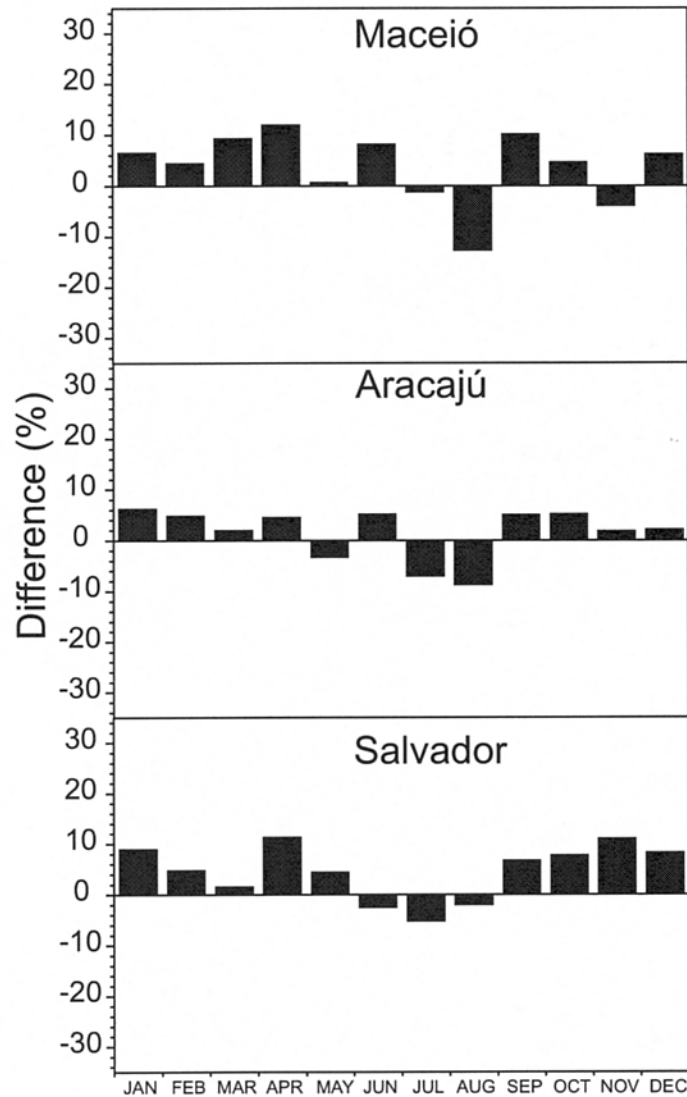


Monthly difference for Brazilian capitals (%)

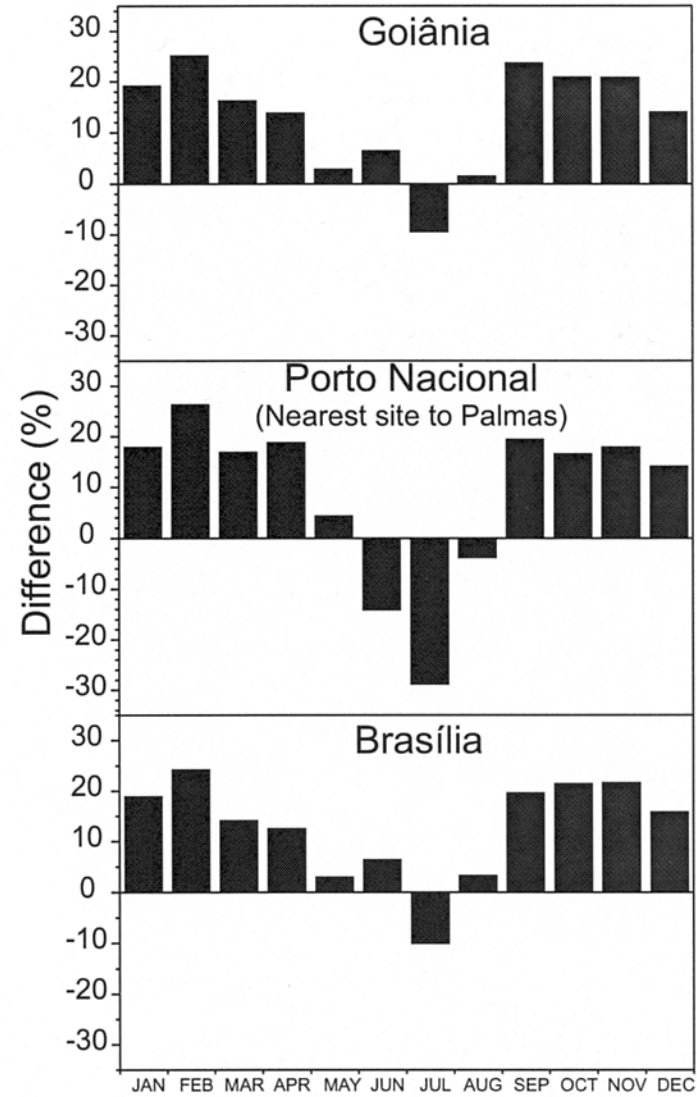


Monthly difference for Brazilian capitals (%)

MONTHLY COMPARISON

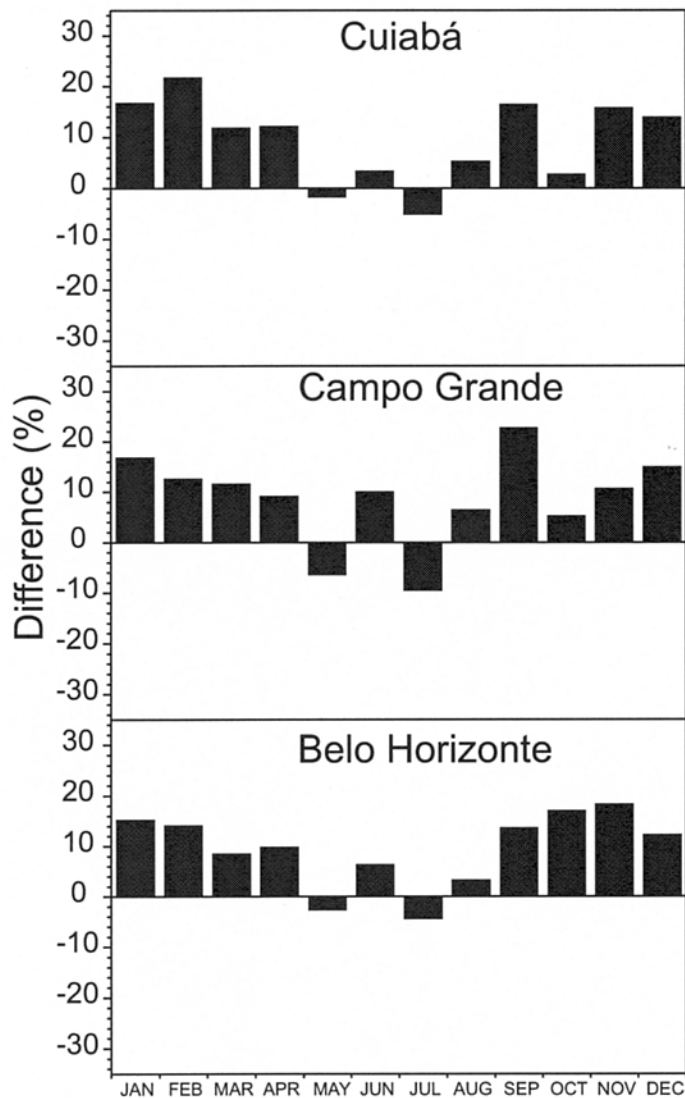


Monthly difference for Brazilian capitals (%)

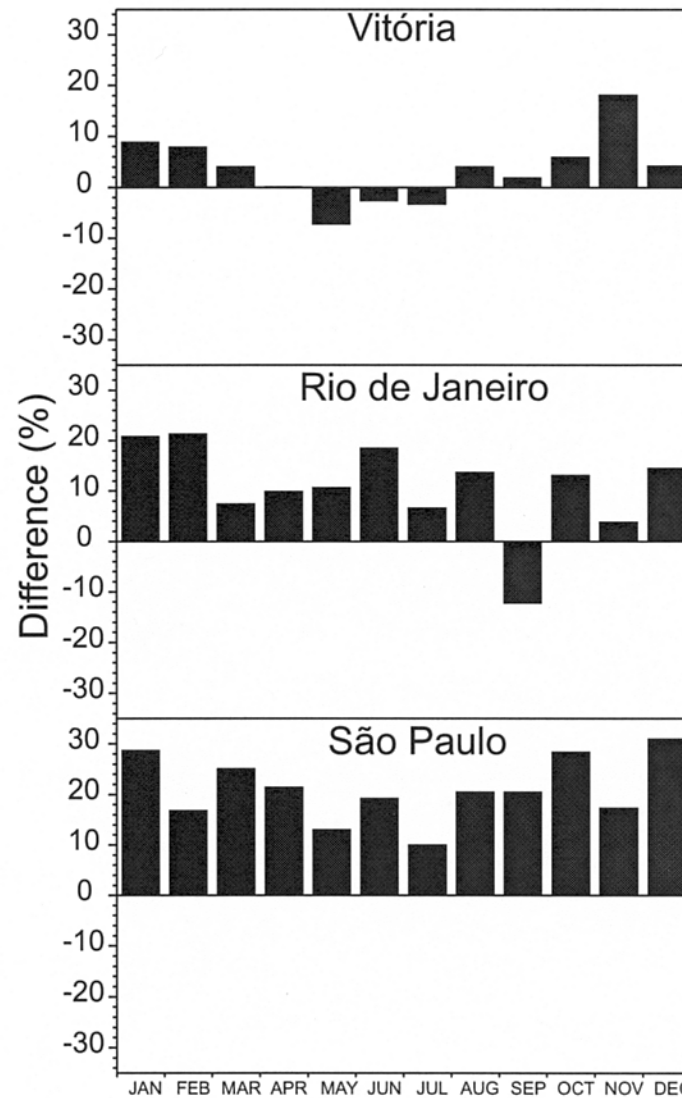


Monthly difference for Brazilian capitals (%)

MONTHLY COMPARISON

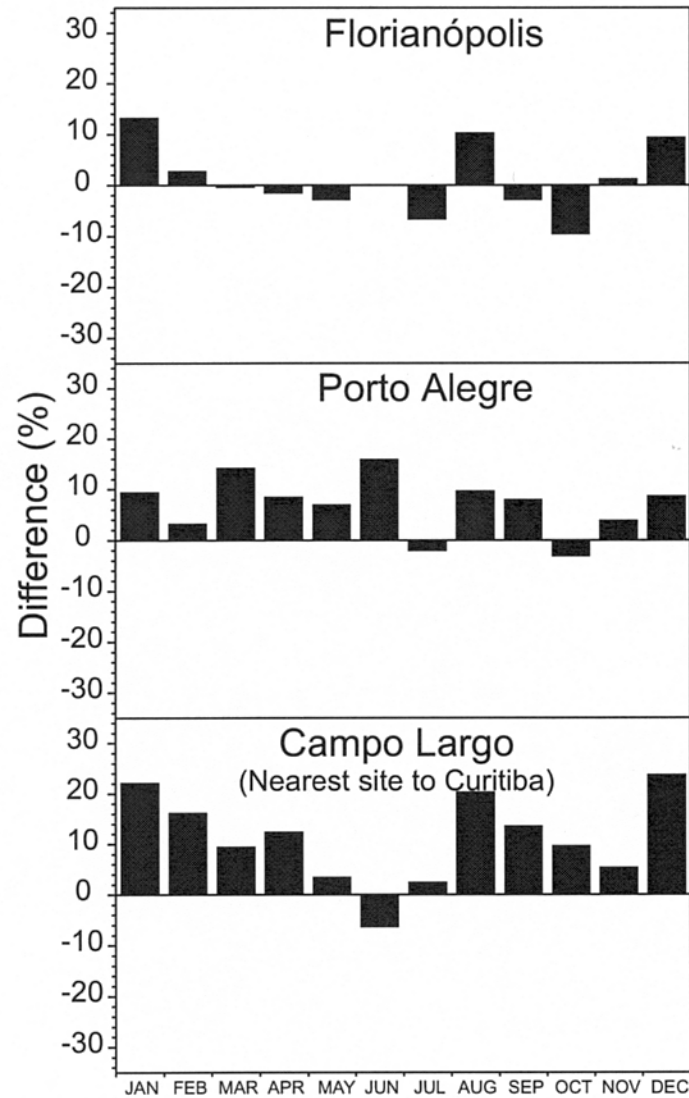


Monthly difference for Brazilian capitals (%)



Monthly difference for Brazilian capitals (%)

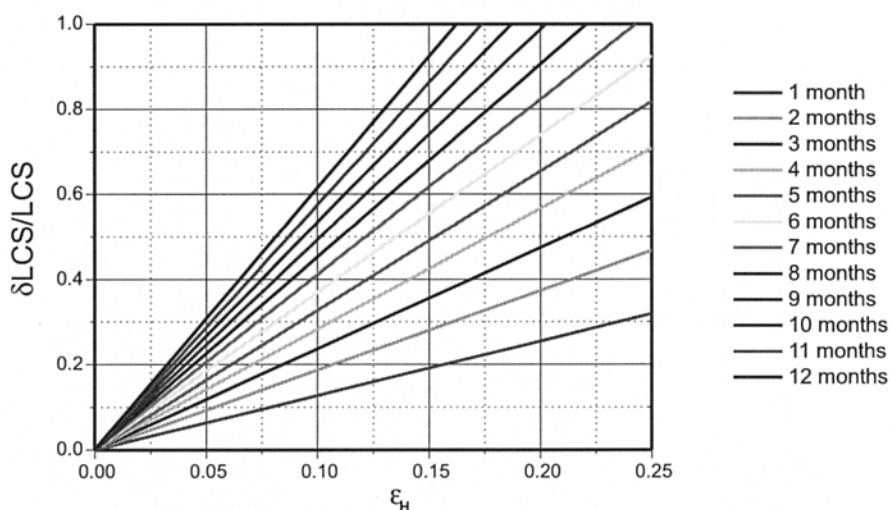
MONTHLY COMPARISON



Monthly difference for Brazilian capitals (%)

Remarks

Uncertainty of monthly means of global radiation in horizontal surfaces plays an important role in the economical analysis of PV plants. The sensitivity of the uncertainty of the LCS - Lifetime Cost Savings of PV plants, in relation to the uncertainty of monthly means of global radiation is shown below. The Figure shows different sensitivity straight lines obtained by the P1 - P2 method, for twelve cases of uncertain months (1 month, 12 cases), (2 months, 66 cases), (3 months, 12! / 3! (12 - 3!) = 220 cases), (etc.). The straight lines represent the average of the results for the respective set of cases. It shows that 5% of uncertainty in the monthly means of twelve months corresponds to 30% of uncertainty in the LCS, for the particular case of US\$ 4,60 / Wp of a PV panel and the electrical energy cost of US\$ 31,80 / GJ (the full analysis is presented in a paper submitted to the 1999 ISES Conference - Jerusalem).



The uncertainty evaluation requires the computation of the correlation coefficient between each two monthly means yearly series. These correlation coefficients appears to stabilize for 30 years series, as is shown in the next tables, for the case of NREL data series for Miami, Los Angeles and Houston. The results for the Brazilian cities of Manaus (Amazon), Campo Grande (southwest) and Porto Alegre (south) are rather poor, once the monthly means are available only for 18 years.

2nd WORKSHOP ON SATELLITES FOR SOLAR ENERGY ASSESSMENTS
Golden, Colorado, USA, February 3-4, 1999



GLOBAL SOLAR RADIATION DATA - BRAZIL - INMET

C = complete
EN = N days estimated
FN = N days failed
BLUE BOX = void

São Luis	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan			E1	C	E5	C	E1	C	E1	E2	E2		
Feb		E2	C	E5	C	E4	C	C	E1	C	E3-F1		
Mar		C	E2	E1	E2	E2	E1	C	E1	E2			
Apr			E6		E2	E1	E1	C	C	C			
May	E12		C		C	E4	E2	C	E1	E5			
Jun	E3		E4		E1	C	F4	C	E1	E2			
Jul	E5		C	E2	E1	E6	E7	C	C	C			
Aug	E12	C	E2	E2	E3	E2	C	C	C	E4			
Sep	E12	E2	E4	E2	C	E4	C	C	C	E2			
Oct	E4	E1	E2	E3	E2	C	C	C	C	C			
Nov	E12	E2	E2	E5	E1	C	C	E3	E3	E1			
Dec	E3	E2	E5	F3	E4	C	E2	E1	E3	E1			

Manaus	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan			F24	C	E1	C	C	C	C	C	F1	C	C
Feb			E5	C	E2	C	C	C	C	C	C	C	C
Mar			E1	C	E2	E1	C	C	C	E1	F1	C	C
Apr			C		E1	C	C	C	C	C	C	E1	C
May					E1	E1	E2	E1	C	E2	C	E1	C
Jun	E2		C		E3	C	C	C	C	C	E2	C	C
Jul	E3		E2	C	C	E1	C	C	C	C	C	C	C
Aug	E1	E1-F1	C	C	C	E1	C	C	C	C	E1	C	C
Sep	E1	E5	E10	C	E1	C	C	C	C	C	E3	C	E1
Oct		E5	E2	C	E1	C	E1	E3	C	C	E7	C	E1
Nov		C	E4	C	C	C	C	E1	C	C	E1	E1	E1
Dec		E3	E6	C	C	C	E1	C	C	E2	F1	C	C

Fortaleza	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan		E4	C	C	E2	E1	C	C	C	C	C	E1	
Feb		E1	E1	E1	E2	E1	C	E1	E1	E1	C	E2	
Mar		E6	C	E4	E3	C	C	C	C	E1	C	C	
Apr		E1	E2		E6	E2	C	E1	E3	C	E1	E1-F16	
May		E2	C		E1	E6	C	C	E1	E2	C		
Jun	E1	E1	E3		E2	E1	C	E1	C	F2	C		
Jul	E1	E1	E1-F1	E1	E1	C	E1	C	E2	E2	C		
Aug	E1	E3	C	E3	E1	C	C	E1	C	E1	C		
Sep	C	C	C	C	C	C	C	E1	E2	E1	C		
Oct	E1	E1	E1	E3	E1	E1	C	C	C	C	E1		
Nov	E4	E6	C	C	E5	C	E1	C	C	C	E1		
Dec	C	E5	E2	C	E3	C	C	C	C	E1	C		

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São Luis	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan			E1	C	E5	C	E1	C	E1	E2	E2		
Feb		E2	C	E5	C	E4	C	C	E1	C	E3-F1		
Mar		C	E2	E1	E2	E2	E1	C	E1	E2			
Apr			E6		E2	E1	E1	C	C	C			
May	E12		C		C	E4	E2	C	E1	E5			
Jun	E3		E4		E1	C	F4	C	E1	E2			
Jul	E5		C	E2	E1	E6	E7	C	C	C			
Aug	E12	C	E2	E2	E3	E2	C	C	C	E4			
Sep	E12	E2	E4	E2	C	E4	C	C	C	E2			
Oct	E4	E1	E2	E3	E2	C	C	C	C	C			
Nov	E12	E2	E2	E5	E1	C	C	E3	E3	E1			
Dec	E3	E2	E5	F3	E4	C	E2	E1	E3	E1			

Manaus	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan			F24	C	E1	C	C	C	C	C	F1	C	C
Feb			E5	C	E2	C	C	C	C	C	C	C	C
Mar			E1	C	E2	E1	C	C	C	E1	F1	C	C
Apr			C		E1	C	C	C	C	C	C	E1	C
May					E1	E1	E2	E1	C	E2	C	E1	C
Jun	E2		C		E3	C	C	C	C	C	E2	C	C
Jul	E3		E2	C	C	E1	C	C	C	C	C	C	C
Aug	E1	E1-F1	C	C	C	E1	C	C	C	C	E1	C	C
Sep	E1	E5	E10	C	E1	C	C	C	C	C	E3	C	E1
Oct		E5	E2	C	E1	C	E1	E3	C	C	E7	C	E1
Nov		C	E4	C	C	C	C	E1	C	C	E1	E1	E1
Dec		E3	E6	C	C	C	E1	C	C	E2	F1	C	C

Fortaleza	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan		E4	C	C	E2	E1	C	C	C	C	C	E1	
Feb		E1	E1	E1	E2	E1	C	E1	E1	E1	C	E2	
Mar		E6	C	E4	E3	C	C	C	C	E1	C	C	
Apr		E1	E2		E6	E2	C	E1	E3	C	E1	E1-F16	
May		E2	C		E1	E6	C	C	E1	E2	C		
Jun	E1	E1	E3		E2	E1	C	E1	C	F2	C		
Jul	E1	E1	E1-F1	E1	E1	C	E1	C	E2	E2	C		
Aug	E1	E3	C	E3	E1	C	C	E1	C	E1	C		
Sep	C	C	C	C	C	C	C	E1	E2	E1	C		
Oct	E1	E1	E1	E3	E1	E1	C	C	C	C	E1		
Nov	E4	E6	C	C	E5	C	E1	C	C	C	E1		
Dec	C	E5	E2	C	E3	C	C	C	C	E1	C		

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Floriano	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan		E2	E2	E1	E6	E4	F10	E1	E1	F3		E4	E1
Feb		E2	E1	E6-F1	E1	C	C	E2	E5	C		C	C
Mar		E5	C	E7	E2	E7	C	E24	C	E3-F2		E1	C
Apr		E3	C		F1	E2	E1		E7	E2-F1		E1	C
May	E8	E2	E6		F5	E1	E3		C	E3		E2	E2
Jun	E4	E3	E2		F6	F1	E3		E2	E1-F1		C	E1
Jul	E6	C	E1	C	E1-F1	C	C	F23	C	F4	E8	C	C
Aug	E2	C	E1	C	E10	E3	E2	C	C	C	C	E3	
Sep	E3	E3	E4	F6	E3	C	E2	E4	E2	F5	C	E1	
Oct	E4	C	E8-F3	E8	E2	C	E1	C	E2		C	C	
Nov	E5	E4	E4	E1	C	C	E3	C	E3		E2	E1	
Dec	C	E2	E4	E2	E3	E6	C	C	C		C	C	

Carolina	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan			E16	E31	E1	E1	C	E4	E2	F23			
Feb	E3	E3	E4	C	C	E1	C	C	E3				
Mar	E3	C	C	E1	C	E3	C	E26	C				
Apr	C	C	C		C	E1	C	C	E2				
May	E3	C	E6		E1	C	C		C				
Jun	E2	C	E2		C	C	C		C	E4			
Jul	E5	C	E16	E1	C		C	C		C			
Aug	E4	C	E16	E1-F1	E10	E7	C	E1		C			
Sep	E5	C	E4	E1	E6	C	E1			E1			
Oct	E5	E1	E8-F3	C	E2	F1	F1	E1	E3	E1			
Nov	E10	E5	E4	E1	E2	C	E5	E1	E1	C			
Dec	E4	C	E4	C	E2	C	C		E3	F23			

Cuiabá	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan			C		E31	C	C	C	C	C	E1	E1	
Feb		E2	E2	E28	E10	C	E19	E1	C	C	C	E1	
Mar		C	C	E31	C	E1		C	C	C	C		
Apr		E3	E4		C	C		E1	C	C	C		
May		E1	C		C	C		C	C	C	C		
Jun		C	E1		C	C		E1	C	C	C		
Jul		C	C	C	C	C		C	E1	E1	C		
Aug	E1	C	E2	E1	C	C	E9	E1	C	C	C		
Sep	C	E1	E5	C	C	C	C	C	C	E1	E1		
Oct	E4	E1	C	C	C	C	C	C	C	C	C		
Nov	E3	E1	E11	E2	C	C	C	C	C	E1	C		
Dec	E2	E1	E31	E22	C	E2	E1	C	C	E1	E1		

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São Paulo	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan	C	C	C	E1	E11	C	E22	E2	E2	C			
Feb	E2	C	C	E1	E27-F1	C	E2	E1-F13	F23	E4			
Mar	C	C	F6	C	E31	C	C	E1	F21	C			
Apr	E3	C	E2		E30	C	C			C			
May	E1	E4	C		F9	C	C		C	C	F3		
Jun	C	C	C		C	C	C		C	F2	C		
Jul	E1	E1	C	C	C	C	C		E1	E1	C		
Aug	C	C	C	E4	C	E2	E5		C	C	C		
Sep	C	C	E1	E1	C	C		F23	C	C	C		
Oct	C	C	E1	C	C	C		C	C	C	C		
Nov	C	E1	C	E1	C	C		C	C	C			
Dec	C		C	C	E2	C	E17	C	E1	C			

Curitiba	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan	E2	C	E4	E1	C	E1	C	C	C	C	C	C	
Feb	E2	E1	E1	E3	C	C	C	C	C	C	C	E1	C
Mar	E2	E1	E1	C	E2	E5	E3	C	E1	C	C	C	
Apr	E2	E1	E3		C	E10	C	C	C	C	E1	C	E1
May	C	E4	C		C	E3	E4	C	C	F1	E2	C	C
Jun	E4	E1	E2		E1	E15	C	C	C	F1	E1	C	C
Jul	E1	E3	E4	C	C	E31	F1	E1	C	C	E2-F1		C
Aug	E9	E1	C	E1	C	C	C	E1	C	C	E1	C	C
Sep	C	C	E1	C	C	E1	E1	E1	C	C	C	C	C
Oct	C	C	C	C	E1	C	E2	C	C	E1	C		C
Nov	E1	C	E3	C	C	C	C	C	C	C	C		C
Dec	C		C	E1	C	E5	C	C	C	C	C	C	E1

SL.Gonsaga	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan							F1	C	F1	C	F1	F2	C
Feb							F1	F1	C	F1	C	C	C
Mar							C	F1	F1	F1	F1	C	C
Apr							C	F1	C	C	C	F1	F1
May							F1	F1	C	C	C	C	F1
Jun							C	F4	C	F4	F2	C	C
Jul							F2	C	C	F1	C	C	F2
Aug							F1	C	C	C	C	C	C
Sep							F1	F1	C	F1	C	F5	C
Oct							F1	F2	C	C	C	C	C
Nov							F1	C	C	C	C	C	F1
Dec							C	F1	C	C	F1	C	F1

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Caravelas	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan	E4	E5	E7	E4	E1	E1	E1	C	E1	F1		F3	C
Feb	E2	E3	E10	E3	C	E3	C	E1		C		C	E1
Mar	E6	E12	E3	E3-F1	C	E2	E1	E1	E1	E1		C	C
Apr	E6	E9	E3		E1	E2	F1	C	E1	E2	E2	E2	
May	E1	E3	E4		E3	E1	E3	C	C	E2	C	E1	
Jun	E3	E4	C		C	E5	C	C	E1	E2	E2	C	
Jul	E3	E6	E3	E8	E2	C	E2	E1	E1	E2	C	E1	
Aug	E3-F1	E7	E3	E3	E3	C	C	E5	C	C	C	C	
Sep	E5	E7	E4	C	E3	E1	C	C	C		C	C	
Oct	E1	E5	E7	C	C	C		C	E4	E1	E1	C	
Nov	E2	C	E8	E1	E4	F1	E2	E2	E1	C	E1	C	
Dec	E2	E6	E10	E3	E1	C	E1	C	E1		C	C	

BELÉM	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan				F2	E31	C	C	E1	E2	C			
Feb			E2	C	E28	C	C	C	E4	E1			
Mar			E1	C	E31	C	C	C	E2	E1			
Apr			E3		E30	E1	C	C	C	C			
May	E20	E6	C		E31	E31	C	C	E1	E2			
Jun	E5	E1	C		E30	E30	C	C	C	E2			
Jul	E3		E1	C	E31	E31	C	C	C	E1			
Aug	C	E3	E1	C	E31	E31	C	C	C	C			
Sep	E27	C	C	C	E30	E19	C	E1	E1	E4			
Oct		C	C	C	E4	E1	C	C	C	E2			
Nov		E2	C	E1	E1	C	C	E2	E2	E4			
Dec		E1	E2	F18	E1	C	C	E1	1E	F23			

Boa Vista	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan					C	C	C	C				F2	
Feb				C	C	F1	C	F2				F10	
Mar				F1	C	C	C	C				C	
Apr					C	F1	C	C				C	
May					C	F1	C	C				C	
Jun					E1	C	F1					C	
Jul				C	C	C	C	F2				F10	
Aug				C	C	F1	F1	F10					
Sep				F1	F1	C	C						
Oct				C	C	C	C						
Nov				F2	C	C	C						
Dec				C	E1	C	C						

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C.GRANDE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan			E31	E2	C	E1	C	C	C	C	C	C	C
Feb		E2	E28-F1	E2	C	C	C	C	C	E2	C	C	C
Mar		E2	E31	C	C	E2	C	C	E1	F6	E1	C	C
Apr			E30		C	E2	C	C	C	E2	C	E1	C
May			E31		E2	E2	E2	C	C	E6	C	C	C
Jun			E30		C	E1	C	C	C	E4	C	E1	C
Jul			E31	C	C	C	C	F13	C	C	C	C	C
Aug	C		C	C	C	C	C	F25	E1		C	C	E2
Sep	E1		E3	E1	C	E1	C	C	C		E1	C	C
Oct	C		E31	C	E1	E1	C	C	E2		C	C	C
Nov	E2		E2	E4	E1	C	E1	C	C		C	C	C
Dec	C		C	C	E2	C	C	C	C	E1	C	C	C

Petrolina	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan	E4	E2	E1	E2	E1	E1		E1	C		C		
Feb	E8	E1	E5	E1	E3	E2		F1	C		E3		
Mar	E7	E4	C	E2	E1	E3	E19	E2		E6	F2 E1		
Apr	E7	C	E1		C	E4	F2	C		E1-F3	E2	E1	
May	E17	E4	E6		C	C	F1	E2		E2-F1	C	E2	
Jun	C	E1	E5		C	C	C	C		F1	E1	C	
Jul	E17	E1	E1	E2	C	C	E2	E1		C	E1	C	
Aug	E4	E3	E1	E3	E1	E1	C	E1		E1		C	
Sep	C	E3	E3	E5	E2	F1	C	C		E2		C	
Oct	E2	E1	E2	E2	C	E2	F2	C	F2	E1			
Nov	E1	C	E9	E1	E30	E1	E4	F15	F9	E1			
Dec	C	E6	E6	C	E6	E31	E2	E9	F7	C			

Salvador	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan	E1	E2	E2	C	C	E3	C	C	E1				
Feb	E1	C	C	C	C	C	C	E1	E1				
Mar	E1	C	C	E1	E1	C	C	E1					
Apr	C	E1	C		C	E2	C	E2				E11	
May	C	C	C		E2	C	C	E1				E4	
Jun	E1-F1	C	C		E1	E12	C	F1				E6	
Jul	E1	C	E3	C	C	E31	C	F18				C	
Aug	E2	C	E2	C	E1	E31	C	C					
Sep	E1	C	E3	C	E6	E2	E1	E1				C	
Oct	E2	C	C	E1	E1	C	C	C				C	
Nov	E6	E1	E1	C	C	C	E1	E1				F19	
Dec	E3	C	C	C	C	C	C	C					

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P Nacional	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan							C	F4	C		C	F6	
Feb							C	C	F18		F2	F6	
Mar							F1	C			F1	F2	
Apr							C	C			F2		
May							F3	C			C		
Jun							C	C		F12	C	C	
Jul							F1	C		C	C	F1	
Aug							C	C		F2	C	F6	
Sep							C	F8		F12	C	C	
Oct							C	F8		C	F1	F3	
Nov							F3	C		C	F1	F5	
Dec							F1	C		C	C	F18	

Brasilia	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan	C	E3	E3	E2	E2	C	E1	E1	E2	C	E2	E2	E3
Feb	C	E3	C	E4	E10	E1	E1	C	E4	C	E1	C	C
Mar	E2	C	E1	E2	E8	C	E1	E5	E3	E3	C	E1	E1
Apr	E1	E2	E2		E24	C	C	C	E8	E5	C		E1
May	E2	C	C		E2	E2	C	E1	E1	E3	E5	C	E1
Jun	C	C	E1		E10	C	C	C	C	E1	C	F15	E4
Jul	E4	E1	E1	E3	E3	C	F1	C	E1	E2	E3	C	C
Aug	E2	E1	C	E1	C	E1	E1	E1	E2	C	E2	C	C
Sep	E15	E2	E2	C	E10	C	E1	E3	C	C	E1	E6	E1
Oct	E2	C	E2	E3	C	E3	E2	C	E2	E1	E1	C	E2
Nov	E12	E2	E4	E2	E2	E1	E3	E2	E2	E1	E1	C	C
Dec	C	E4	E4	F1	C	E1	E1	E2	E1	E3	C	C	E5

Bagé	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan							C	F1	C		C	C	C
Feb							F1	C			C	F2	C
Mar							F3	F1			C	C	C
Apr							C	F6			C	C	F1
May							C				C	C	C
Jun							C				F1	C	F12
Jul							C			C	C	C	
Aug							F1			C	C	C	
Sep							C			C	C	C	
Oct							C			C		C	C
Nov							C			C	C	C	C
Dec							C	F18		C	C	C	C

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P. Alegre	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Jan	E9	C	C	C	C	C	C	C	C	C	C	C	C
Feb		C	C	C	C	C	C	E9	C	F1	C	C	E1
Mar		C	C	C	E1	C	C	E18	F4	C	C	C	C
Apr		C	C		C	C	C	C	C	C	C	E2	E3
May	E11	C	C		C	C	C	E2	C	C	C	C	C
Jun	C	C	C		E1	C	C	E2-F1	E1	C	C	C	C
Jul	C	C	C	C	F22	C	C	C	C	C	C	C	C
Aug	C	C	E1	C	E29	C	C	C	C	C	C	C	C
Sep	E1	C	E1	C	E29	C	C	C	C	C	C	E1	E2
Oct	C	C	C	C	C	C	C	F17	E3	E1	C	C	C
Nov	C	C	C	C	E1	C	C	C	C	C	E1	E1	C
Dec	C	C	C	C	C	C	C	C	C	C	E2	E3	C

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Houston **Cross Correlation of Monthly Means - 30 YEARS** **1961 to 1990**

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,180	1										
mar	0,068	-0,048	1									
apr	-0,004	0,160	0,359	1								
may	-0,081	0,174	-0,044	0,232	1							
jun	-0,022	0,158	-0,142	0,110	0,006	1						
jul	-0,110	0,186	-0,002	0,158	0,056	0,019	1					
aug	0,123	-0,185	-0,225	0,068	0,258	0,052	0,098	1				
sep	0,123	-0,484	-0,285	-0,112	-0,139	0,051	-0,182	0,230	1			
oct	-0,363	-0,387	0,191	0,016	-0,160	0,279	-0,248	-0,055	0,106	1		
nov	-0,191	-0,307	-0,176	-0,038	0,131	0,149	-0,087	0,233	0,327	0,389	1	
dec	-0,266	-0,329	-0,342	-0,045	0,285	0,024	0,008	-0,008	0,259	0,123	0,374	1

Houston **Cross Correlation of Monthly Means - 29 YEARS** **1962 to 1990**

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,178	1										
mar	0,069	-0,047	1									
apr	0,001	0,170	0,359	1								
may	-0,079	0,181	-0,045	0,226	1							
jun	-0,036	0,143	-0,142	0,148	0,027	1						
jul	-0,147	0,169	0,008	0,239	0,101	-0,129	1					
aug	0,116	-0,204	-0,225	0,092	0,277	-0,002	0,009	1				
sep	0,124	-0,484	-0,285	-0,114	-0,140	0,055	-0,200	0,236	1			
oct	-0,362	-0,385	0,190	0,011	-0,164	0,305	-0,255	-0,046	0,106	1		
nov	-0,197	-0,317	-0,175	-0,028	0,139	0,127	-0,149	0,219	0,330	0,396	1	
dec	-0,266	-0,329	-0,342	-0,047	0,285	0,028	0,015	-0,006	0,259	0,122	0,377	1

Houston **Cross Correlation of Monthly Means - 28 YEARS** **1963 to 1990**

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,175	1										
mar	0,068	-0,049	1									
apr	-0,001	0,168	0,358	1								
may	-0,069	0,213	-0,038	0,248	1							
jun	-0,050	0,127	-0,155	0,142	0,110	1						
jul	-0,141	0,219	0,022	0,277	-0,013	-0,030	1					
aug	0,130	-0,192	-0,224	0,104	0,229	0,059	-0,088	1				
sep	0,120	-0,496	-0,289	-0,118	-0,119	0,033	-0,180	0,264	1			
oct	-0,362	-0,386	0,190	0,011	-0,172	0,317	-0,279	-0,048	0,106	1		
nov	-0,194	-0,313	-0,173	-0,025	0,124	0,151	-0,193	0,209	0,338	0,397	1	
dec	-0,282	-0,356	-0,358	-0,057	0,369	-0,029	0,111	0,045	0,246	0,126	0,402	1

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Houston		Cross Correlation of Monthly Means - 27 YEARS								1964 to 1990			
ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	
jan	1												
feb	0,201	1											
mar	0,064	-0,044	1										
apr	0,004	0,164	0,360	1									
may	-0,069	0,216	-0,038	0,248	1								
jun	-0,070	0,158	-0,162	0,150	0,111	1							
jul	-0,146	0,229	0,021	0,279	-0,013	-0,036	1						
aug	0,143	-0,212	-0,222	0,101	0,230	0,075	-0,086	1					
sep	0,128	-0,514	-0,288	-0,120	-0,119	0,042	-0,178	0,261	1				
oct	-0,359	-0,402	0,192	0,009	-0,172	0,329	-0,278	-0,053	0,104	1			
nov	-0,209	-0,301	-0,177	-0,021	0,125	0,138	-0,197	0,220	0,346	0,404	1		
dec	-0,300	-0,343	-0,364	-0,053	0,372	-0,047	0,108	0,055	0,254	0,133	0,396	1	

Houston		Cross Correlation of Monthly Means - 26 YEARS								1965 to 1990			
ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	
jan	1												
feb	0,201	1											
mar	0,074	-0,044	1										
apr	-0,033	0,167	0,397	1									
may	-0,087	0,217	-0,029	0,222	1								
jun	-0,080	0,158	-0,158	0,134	0,102	1							
jul	-0,160	0,229	0,028	0,264	-0,026	-0,043	1						
aug	0,137	-0,213	-0,219	0,090	0,225	0,071	-0,091	1					
sep	0,091	-0,552	-0,281	-0,240	-0,177	0,016	-0,226	0,258	1				
oct	-0,342	-0,411	0,180	0,082	-0,146	0,359	-0,264	-0,042	0,205	1			
nov	-0,234	-0,307	-0,168	-0,070	0,106	0,128	-0,216	0,215	0,314	0,462	1		
dec	-0,341	-0,356	-0,357	-0,127	0,354	-0,068	0,088	0,044	0,191	0,200	0,373	1	

Houston		Cross Correlation of Monthly Means - 25 YEARS								1966 to 1990			
ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	
jan	1												
feb	0,253	1											
mar	0,094	-0,046	1										
apr	-0,013	0,164	0,396	1									
may	0,108	0,203	-0,048	0,222	1								
jun	-0,125	0,166	-0,156	0,139	0,159	1							
jul	-0,183	0,232	0,029	0,266	-0,018	-0,045	1						
aug	0,217	-0,229	-0,226	0,083	0,177	0,086	-0,089	1					
sep	0,124	-0,560	-0,284	-0,244	-0,229	0,021	-0,225	0,253	1				
oct	-0,399	-0,408	0,183	0,086	-0,131	0,356	-0,266	-0,032	0,210	1			
nov	-0,185	-0,326	-0,176	-0,080	0,034	0,145	-0,216	0,194	0,309	0,481	1		
dec	-0,319	-0,371	-0,365	-0,135	0,333	-0,057	0,092	0,025	0,185	0,211	0,360	1	

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Los Angeles Cross Correlation of Monthly Means - 30 YEARS 1961 to 1990

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,197	1										
mar	0,238	0,166	1									
apr	-0,247	0,044	0,172	1								
may	0,206	0,180	0,132	-0,135	1							
jun	-0,103	0,239	0,009	-0,027	0,166	1						
jul	-0,400	0,035	-0,327	-0,132	0,060	0,024	1					
aug	0,077	0,040	0,065	-0,031	0,023	0,259	0,139	1				
sep	-0,092	0,171	0,061	0,087	0,381	0,014	0,263	-0,093	1			
oct	0,123	0,061	-0,037	-0,472	-0,041	0,000	0,132	0,100	-0,177	1		
nov	0,042	-0,120	-0,080	0,120	0,095	0,240	-0,087	-0,078	0,152	0,008	1	
dec	-0,047	-0,297	-0,254	-0,047	-0,119	0,258	-0,026	0,127	-0,126	-0,002	0,382	1

Los Angeles Cross Correlation of Monthly Means - 29 YEARS 1962 to 1990

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,174	1										
mar	0,223	0,143	1									
apr	-0,284	0,005	0,149	1								
may	0,187	0,152	0,112	-0,175	1							
jun	-0,114	0,231	0,000	-0,042	0,157	1						
jul	-0,395	0,051	-0,321	-0,119	0,074	0,029	1					
aug	0,094	0,063	0,081	-0,010	0,042	0,269	0,132	1				
sep	-0,100	0,165	0,055	0,079	0,379	0,011	0,268	-0,088	1			
oct	0,121	0,057	-0,041	-0,487	-0,046	-0,001	0,134	0,103	-0,179	1		
nov	0,049	-0,114	-0,074	0,132	0,104	0,244	-0,091	-0,084	0,155	0,009	1	
dec	-0,033	-0,284	-0,243	-0,033	-0,104	0,267	-0,034	0,117	-0,121	0,001	0,380	1

Los Angeles Cross Correlation of Monthly Means - 28 YEARS 1963 to 1990

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,232	1										
mar	0,226	0,150	1									
apr	-0,283	-0,005	0,149	1								
may	0,166	0,218	0,114	-0,172	1							
jun	-0,089	0,186	0,000	-0,048	0,196	1						
jul	-0,382	0,011	-0,324	-0,125	0,099	0,005	1					
aug	0,059	0,148	0,084	-0,002	-0,001	0,331	0,172	1				
sep	-0,126	0,225	0,056	0,085	0,362	0,041	0,295	-0,132	1			
oct	0,148	0,011	-0,042	-0,498	-0,019	-0,032	0,115	0,149	-0,158	1		
nov	0,057	-0,134	-0,074	0,130	0,114	0,240	-0,098	-0,075	0,164	0,002	1	
dec	-0,031	-0,302	-0,243	-0,031	-0,103	0,270	-0,037	0,124	-0,121	-0,001	0,380	1

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Los Angeles Cross Correlation of Monthly Means - 27 YEARS 1964 to 1990

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,233	1										
mar	0,229	0,170	1									
apr	-0,285	0,003	0,135	1								
may	0,174	0,202	0,172	-0,155	1							
jun	-0,089	0,177	0,023	-0,038	0,172	1						
jul	-0,391	0,029	-0,374	-0,146	0,157	0,029	1					
aug	0,059	0,160	0,063	-0,012	0,030	0,350	0,153	1				
sep	-0,126	0,226	0,057	0,085	0,376	0,042	0,300	-0,134	1			
oct	0,152	-0,004	-0,011	-0,492	-0,065	-0,053	0,152	0,171	-0,160	1		
nov	0,057	-0,139	-0,066	0,135	0,105	0,236	-0,091	-0,069	0,165	-0,006	1	
dec	-0,037	-0,290	-0,343	-0,037	-0,009	0,341	-0,118	0,088	-0,131	0,065	0,429	1

Los Angeles Cross Correlation of Monthly Means - 26 YEARS 1965 to 1990

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,150	1										
mar	0,212	0,140	1									
apr	-0,289	0,018	0,138	1								
may	0,138	0,139	0,157	-0,152	1							
jun	-0,053	0,284	0,041	-0,043	0,208	1						
jul	-0,460	-0,070	-0,405	-0,143	0,125	0,064	1					
aug	0,085	0,230	0,074	-0,016	0,050	0,339	0,179	1				
sep	-0,170	0,174	0,041	0,091	0,357	0,071	0,276	-0,119	1			
oct	0,200	0,083	0,007	-0,505	-0,035	-0,084	0,194	0,157	-0,135	1		
nov	0,071	-0,130	-0,061	0,134	0,116	0,231	-0,082	-0,075	0,176	-0,016	1	
dec	0,066	-0,131	-0,332	0,066	0,072	0,304	-0,038	0,051	-0,071	-0,007	0,448	1

Los Angeles Cross Correlation of Monthly Means - 25 YEARS 1966 to 1990

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,141	1										
mar	0,212	0,140	1									
apr	-0,265	0,061	0,151	1								
may	0,130	0,129	0,157	-0,127	1							
jun	-0,027	0,334	0,046	-0,157	0,247	1						
jul	-0,452	-0,049	-0,411	-0,224	0,147	0,010	1					
aug	0,113	0,271	0,079	-0,113	0,077	0,287	0,137	1				
sep	-0,177	0,168	0,040	0,120	0,353	0,093	0,294	-0,107	1			
oct	0,192	0,072	0,006	-0,503	-0,045	-0,057	0,219	0,190	-0,143	1		
nov	0,122	-0,091	-0,063	-0,011	0,174	0,126	-0,182	-0,209	0,224	0,031	1	
dec	0,079	-0,118	-0,334	0,079	0,086	0,280	-0,065	0,019	-0,064	0,006	0,437	1

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Miami Cross Correlation of Monthly Means - 30 YEARS 1961 to 1990

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,190	1										
mar	0,292	0,228	1									
apr	0,146	0,005	0,494	1								
may	0,265	0,221	0,122	0,182	1							
jun	0,290	-0,058	-0,025	0,223	0,250	1						
jul	0,085	0,334	0,226	0,401	0,290	0,391	1					
aug	-0,234	-0,061	-0,047	0,297	-0,082	0,020	0,302	1				
sep	-0,080	0,423	0,015	0,358	0,274	0,140	0,266	0,285	1			
oct	0,103	0,147	0,439	0,442	0,066	0,163	0,112	-0,196	0,358	1		
nov	-0,178	-0,065	-0,072	-0,090	-0,210	-0,284	-0,160	0,089	0,039	-0,054	1	
dec	0,043	0,264	0,083	-0,046	0,109	-0,060	0,133	0,228	0,218	0,087	0,631	1

Miami Cross Correlation of Monthly Means - 29 YEARS 1962 to 1990

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,195	1										
mar	0,304	0,213	1									
apr	0,153	-0,013	0,477	1								
may	0,268	0,216	0,113	0,175	1							
jun	0,300	-0,077	-0,061	0,200	0,244	1						
jul	0,093	0,321	0,195	0,380	0,284	0,370	1					
aug	-0,232	-0,076	-0,075	0,282	-0,091	-0,002	0,284	1				
sep	-0,074	0,423	-0,084	0,321	0,277	0,071	0,203	0,255	1			
oct	0,119	0,121	0,405	0,415	0,050	0,117	0,054	-0,252	0,257	1		
nov	-0,175	-0,087	-0,113	-0,126	-0,226	-0,327	-0,205	0,066	-0,051	-0,120	1	
dec	0,052	0,248	0,039	-0,088	0,098	-0,104	0,091	0,205	0,131	0,016	0,615	1

Miami Cross Correlation of Monthly Means - 28 YEARS 1963 to 1990

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,215	1										
mar	0,309	0,195	1									
apr	0,151	0,018	0,491	1								
may	0,290	0,140	0,090	0,215	1							
jun	0,298	-0,053	-0,053	0,193	0,284	1						
jul	0,095	0,327	0,193	0,385	0,288	0,374	1					
aug	-0,243	-0,018	-0,058	0,269	-0,036	-0,020	0,296	1				
sep	-0,073	0,436	-0,087	0,325	0,282	0,074	0,202	0,265	1			
oct	0,128	0,067	0,396	0,445	-0,007	0,137	0,050	-0,223	0,257	1		
nov	-0,177	-0,078	-0,110	-0,130	-0,224	-0,332	-0,204	0,059	-0,050	-0,114	1	
dec	0,058	0,210	0,024	-0,073	0,052	-0,091	0,087	0,246	0,129	-0,016	0,632	1

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Miami Cross Correlation of Monthly Means - 27 YEARS 1964 to 1990

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,212	1										
mar	0,349	0,275	1									
apr	0,170	0,068	0,423	1								
may	0,297	0,161	0,045	0,187	1							
jun	0,305	-0,035	-0,110	0,163	0,272	1						
jul	0,117	0,419	0,052	0,302	0,262	0,356	1					
aug	-0,241	0,001	-0,119	0,241	-0,054	-0,037	0,267	1				
sep	-0,087	0,416	0,026	0,455	0,334	0,115	0,352	0,318	1			
oct	0,133	0,087	0,379	0,430	-0,023	0,123	0,001	-0,244	0,308	1		
nov	-0,178	-0,085	-0,101	-0,123	-0,221	-0,329	-0,203	0,066	-0,065	-0,110	1	
dec	0,058	0,214	0,021	-0,081	0,051	-0,093	0,090	0,246	0,138	-0,018	0,633	1

Miami Cross Correlation of Monthly Means - 26 YEARS 1965 to 1990

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,217	1										
mar	0,328	0,275	1									
apr	0,178	0,068	0,426	1								
may	0,337	0,163	0,057	0,187	1							
jun	0,343	-0,034	-0,102	0,163	0,268	1						
jul	0,153	0,423	0,066	0,304	0,256	0,351	1					
aug	-0,231	0,002	-0,111	0,242	-0,060	-0,043	0,262	1				
sep	-0,085	0,416	0,028	0,455	0,334	0,114	0,352	0,318	1			
oct	0,065	0,086	0,361	0,444	-0,003	0,147	0,026	-0,234	0,322	1		
nov	-0,226	-0,088	-0,119	-0,124	-0,213	-0,324	-0,193	0,075	-0,063	-0,146	1	
dec	-0,037	0,221	-0,021	-0,085	0,081	-0,073	0,128	0,284	0,151	-0,104	0,631	1

Miami Cross Correlation of Monthly Means - 25 YEARS 1966 to 1990

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,218	1										
mar	0,328	0,299	1									
apr	0,178	0,075	0,426	1								
may	0,334	0,128	0,056	0,188	1							
jun	0,340	-0,079	-0,103	0,164	0,261	1						
jul	0,156	0,494	0,066	0,304	0,265	0,358	1					
aug	-0,226	0,070	-0,111	0,244	-0,045	-0,031	0,258	1				
sep	-0,096	0,383	0,027	0,462	0,321	0,100	0,368	0,352	1			
oct	0,068	0,118	0,362	0,445	0,003	0,152	0,024	-0,244	0,337	1		
nov	-0,221	0,032	-0,121	-0,129	-0,191	-0,313	-0,216	0,038	-0,016	-0,166	1	
dec	-0,033	0,286	-0,020	-0,086	0,092	-0,066	0,124	0,275	0,169	-0,109	0,633	1

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Manaus **Cross Correlation of Monthly Means - 18 YEARS** **1961 to 1978**

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,605	1										
mar	0,581	0,413	1									
apr	0,439	0,615	0,407	1								
may	0,239	0,420	0,310	0,330	1							
jun	0,372	0,500	0,276	0,124	0,385	1						
jul	-0,009	0,351	-0,094	0,322	0,482	0,335	1					
aug	0,137	0,349	-0,258	0,388	0,387	0,197	0,652	1				
sep	0,224	0,425	0,316	0,445	0,701	0,380	0,566	0,436	1			
oct	0,440	0,523	-0,191	0,602	0,392	0,334	0,179	0,209	0,413	1		
nov	0,595	0,610	0,296	0,289	0,516	0,277	0,233	0,469	0,438	0,299	1	
dec	0,340	0,484	0,474	0,272	0,299	0,108	0,353	-0,085	0,450	0,397	0,198	1

Manaus **Cross Correlation of Monthly Means - 17 YEARS** **1962 to 1978**

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,576	1										
mar	0,548	0,371	1									
apr	0,375	0,578	0,344	1								
may	0,189	0,385	0,267	0,271	1							
jun	0,436	0,565	0,332	0,201	0,437	1						
jul	-0,066	0,318	-0,153	0,274	0,458	0,377	1					
aug	0,029	0,277	-0,413	0,274	0,332	0,288	0,640	1				
sep	0,154	0,377	0,257	0,372	0,682	0,454	0,543	0,358	1			
oct	0,475	0,557	-0,180	0,678	0,417	0,330	0,194	0,256	0,453	1		
nov	0,552	0,579	0,192	0,108	0,480	0,429	0,156	0,326	0,342	0,391	1	
dec	0,333	0,482	0,471	0,264	0,290	0,122	0,346	-0,127	0,449	0,404	0,186	1

Manaus **Cross Correlation of Monthly Means - 16 YEARS** **1963 to 1978**

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1,000											
feb	0,609	1,000										
mar	0,521	0,426	1,000									
apr	0,375	0,585	0,350	1,000								
may	0,155	0,412	0,219	0,268	1,000							
jun	0,417	0,591	0,298	0,198	0,418	1,000						
jul	-0,101	0,338	-0,219	0,271	0,441	0,360	1,000					
aug	-0,007	0,298	-0,506	0,271	0,308	0,267	0,630	1,000				
sep	0,078	0,458	0,141	0,392	0,673	0,429	0,531	0,319	1,000			
oct	0,450	0,594	-0,323	0,687	0,391	0,305	0,166	0,226	0,408	1,000		
nov	0,550	0,590	0,178	0,105	0,475	0,424	0,147	0,319	0,343	0,385	1,000	
dec	0,291	0,535	0,414	0,264	0,248	0,076	0,317	-0,191	0,375	0,363	0,173	1,000



Manaus **Cross Correlation of Monthly Means - 15 YEARS** **1964 to 1978**

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,623	1										
mar	0,562	0,429	1									
apr	0,343	0,602	0,393	1								
may	0,084	0,445	0,289	0,198	1							
jun	0,399	0,597	0,322	0,168	0,394	1						
jul	-0,209	0,371	-0,187	0,196	0,338	0,360	1					
aug	-0,088	0,319	-0,500	0,205	0,200	0,230	0,567	1				
sep	0,017	0,479	0,187	0,346	0,633	0,407	0,470	0,239	1			
oct	0,432	0,602	-0,400	0,676	0,361	0,287	0,111	0,183	0,382	1		
nov	0,618	0,602	0,158	0,161	0,610	0,470	0,258	0,427	0,431	0,432	1	
dec	0,302	0,535	0,415	0,277	0,276	0,080	0,357	-0,197	0,399	0,372	0,172	1

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Porto Alegre Cross Correlation of Monthly Means - 18 YEARS 1961 to 1978

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,370	1										
mar	0,052	-0,128	1									
apr	-0,126	0,036	0,235	1								
may	0,282	0,096	0,318	-0,025	1							
jun	0,159	-0,127	0,346	0,147	0,215	1						
jul	0,164	0,070	-0,317	0,106	0,144	0,161	1					
aug	0,056	-0,162	-0,114	-0,144	0,237	0,302	0,229	1				
sep	0,110	-0,046	-0,411	-0,026	-0,287	-0,158	-0,127	0,187	1			
oct	0,200	-0,165	-0,356	-0,288	0,092	0,502	0,200	0,595	0,362	1		
nov	0,413	0,192	-0,035	-0,512	0,168	0,259	-0,087	0,308	0,328	0,465	1	
dec	0,056	0,037	0,192	0,286	0,152	0,300	-0,170	0,266	-0,194	0,137	-0,006	1

Porto Alegre Cross Correlation of Monthly Means - 17 YEARS 1962 to 1978

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,360	1										
mar	0,051	-0,133	1									
apr	-0,100	0,095	0,253	1								
may	0,268	0,060	0,322	0,047	1							
jun	0,173	-0,108	0,351	0,115	0,250	1						
jul	0,166	0,075	-0,317	0,105	0,152	0,160	1					
aug	0,021	-0,246	-0,129	-0,032	0,172	0,377	0,254	1				
sep	0,179	0,040	-0,458	-0,207	-0,213	-0,248	-0,154	0,442	1			
oct	0,208	-0,155	-0,356	-0,327	0,110	0,498	0,200	0,670	0,375	1		
nov	0,404	0,167	-0,039	-0,489	0,135	0,288	-0,085	0,265	0,475	0,486	1	
dec	0,022	-0,027	0,199	0,449	0,081	0,373	-0,175	0,154	-0,029	0,174	-0,076	1

Porto Alegre Cross Correlation of Monthly Means - 16 YEARS 1963 to 1978

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,346	1										
mar	-0,041	-0,174	1									
apr	-0,140	0,084	0,230	1								
may	0,353	0,048	0,301	0,033	1							
jun	0,059	-0,169	0,255	0,073	0,219	1						
jul	0,284	0,114	-0,242	0,151	0,204	0,344	1					
aug	-0,070	-0,291	-0,243	-0,070	0,142	0,291	0,384	1				
sep	0,153	0,029	-0,523	-0,224	-0,231	-0,331	-0,124	0,430	1			
oct	0,126	-0,202	-0,509	-0,389	0,074	0,419	0,340	0,634	0,359	1		
nov	0,353	0,145	-0,135	-0,544	0,106	0,197	0,002	0,200	0,464	0,436	1	
dec	-0,169	-0,101	0,037	0,465	0,016	0,184	-0,001	-0,011	-0,112	-0,008	-0,281	1

2nd WORKSHOP ON SATELLITES FOR SOLAR ENERGY ASSESSMENTS
Golden, Colorado, USA, February 3-4, 1999



Porto Alegre Cross Correlation of Monthly Means - 15 YEARS 1964 to 1978

ρ	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
jan	1											
feb	0,384	1										
mar	0,159	-0,182	1									
apr	0,072	0,099	0,087	1								
may	0,361	0,051	0,266	-0,036	1							
jun	0,236	-0,173	0,161	-0,064	0,183	1						
jul	0,385	0,117	-0,310	0,112	0,189	0,325	1					
aug	-0,256	-0,311	-0,145	0,073	0,202	0,425	0,446	1				
sep	-0,493	0,033	-0,419	0,270	-0,191	-0,150	-0,047	0,326	1			
oct	-0,058	-0,223	-0,431	-0,274	0,142	0,601	0,417	0,588	0,090	1		
nov	0,151	0,161	0,069	-0,420	0,217	0,430	0,074	0,050	0,073	0,308	1	
dec	-0,153	-0,100	0,011	0,481	0,005	0,170	-0,009	0,012	-0,093	0,020	-0,285	1

4. Satellite Derived Solar Radiation for Argentina

The radiation distribution was determined by the regression equation of Tarpley and the validation against the ground truth of 80 pyranometers is reported by Friulla et. All. in **Solar Energy**, International Journal, in 1982. The atlas derived from this work is not available in South America.

PROJECTS IN SOUTH AMERICA

1. ARGENTINA

A project is being developed in partnership with Spain and Portugal. The project focuses the assessment of solar irradiation data from ground stations. The coordinator of the project is Dr. H. Grossi - Gallegos. To the best of my knowledge, the proposed method to obtain the distribution of solar radiation is not published. We are still in contact with Dr. Grossi in order to get more details about the organization of the project as well as the technical informations concerned.

2. BRAZIL

The aim of the project is the assessment of the global, direct and diffuse irradiation as well as the solar irradiation on inclined surfaces for PV and other applications. The project is organized under the leadership of LABSOLAR/NCTS with the partnership of INPE (Brazilian Institute for Space Research) and INMET. Minor partners are the utility company ELETROBRAS (Federal) and CELESC - Utility Company of the State of Santa Catarina.

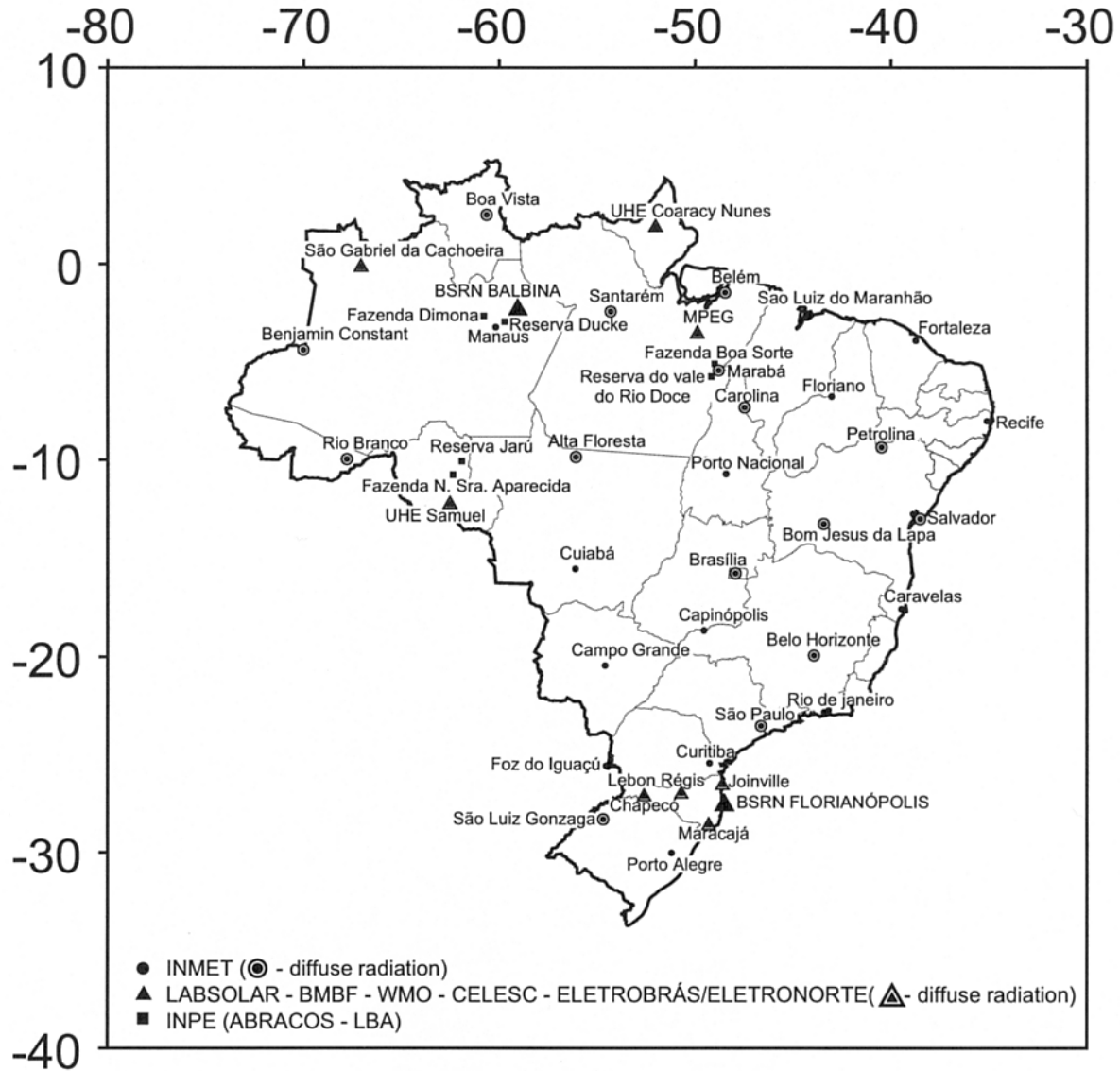
Goals of the project:

- (i) - To rebuild the National Ground Station Network - RSNA (the old network is completely out of work since 1991);
- (ii) - To validate satellite derived radiation (SDR) for Brazilian territory;
- (iii) - To provide radiation data of highest quality for scientific use (BSRN goal);
- (iv) - To extend the computation of SDR to South America;
- (v) - To validate SDR for South America (it is presently the most difficult task). The location and type of the ground stations is shown in the next figure.

National Ground Stations Network - RSNA



(INMET, LABSOLAR, BMBF, BSRN/WMO, INPE, SIVAM, USP, UFPA, URGs, ...)



Project Status:

- ☑ 6 stations of LABSOLAR (2 BSRN), 2 GAW - INMET stations, 3 stations of INPE are available.
- ☑ The computer model (Brazil-SR) is fully operational at LABSOLAR.
- ☑ INPE provides the GOES 8 VIS images with one hour and three hour resolution.
- ☑ RSNA is planned in the frame of the deployment of the new standard meteorological stations of INMET which are presently being installed.
- ☑ ICA - International Cooperation Agency is responsible for the procurement and purchasing the radiometers and shade rings.
- ☑ The funds planned for the project proposed to INMET is still not available.

Present Needs:

- ☑ An international cooperation project for South America should be planned.
- ☑ The budget should be planned and the funds should be independent of national governments.
- ☑ The scientific staff should be defined by an international scientific committee.
- ☑ The project should be financed by an international agency.
- ☑ Minor financial counterparts should come from national agencies.