

Evaluation of Solar Energy Potential and its Variability in the Azores

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Evaluation of Solar Energy Potential and its Variability in the Azores

- Instruments and stations
- Data processing
- Results

Instruments & Data Acquisition



- **Pyranometers** instruments are specially designed for regular and continuous measurement of global radiation between $0.3 \mu\text{m}$ and $3.0 \mu\text{m}$.
- IM network have installed Kipp & Zonen CM11 thermoelectric pyranometers ("high quality" - Guide to Meteorological Instruments and Methods of Observation, VI ed.).
- AWS MILUS 500 (Vaisala):
 - Sampling Interval: < 30 seg
 - Integration Time: 10 min
 - Time Of Observation: TST

Stations

Corvo



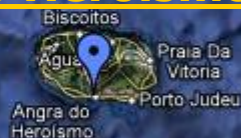
Flores



Graciosa



A. do Heroísmo



Pico



Horta

Nordeste



P. Delgada

S. Maria



Calibration & Data Processing & Archiving

- Much attention is being given to the calibration of the radiation sensors - ISO 9846:1993(E);
Last calibration of sensors were done on Oct-Nov/2009.
- Measurements are carefully analysed applying Quality Control /Quality Assessment (QC/QA) procedures;
- Once the control procedures are completed, the final data are centralised in a database system.

Data processing for row and 10' data:

- [TSV] contains the all information collected at all stations;
- Extract and set by time (10 minutes average) raw-data recorded:
- [RAD] station/monthly data files whith 10' data.

- 10' data values control:

c
c **iflag = 0 : (good)**
c **= 1 : > 0.9*x0 (bad)**
c **= 2 : 0.8*x0 = <x> 0.9*x0 (suspect)**
c

x0: Extraterrestrial irradiance

Data processing for hourly data (1):

- Building [*.hor] files:

- c To each hour H is assigned an integrated value between H-1 and H.

- c For example, the total value at 5:00 TST is obtained by integrating of the

- c 4:10, 4:20, ..., 4:50 and 5:00.

- Zero hourly values are considered wrong and set to missing (-1).

Data processing for hourly data (2):

- Building [*.ho1] files:

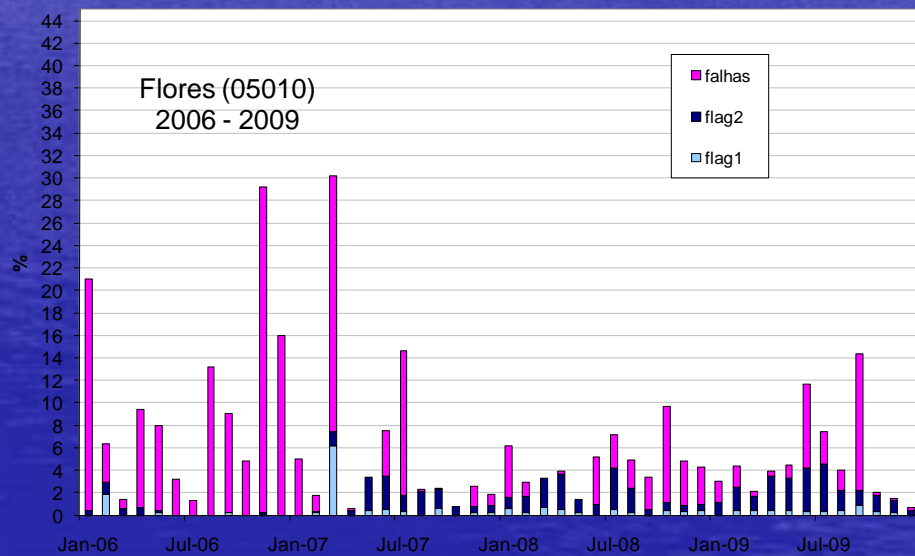
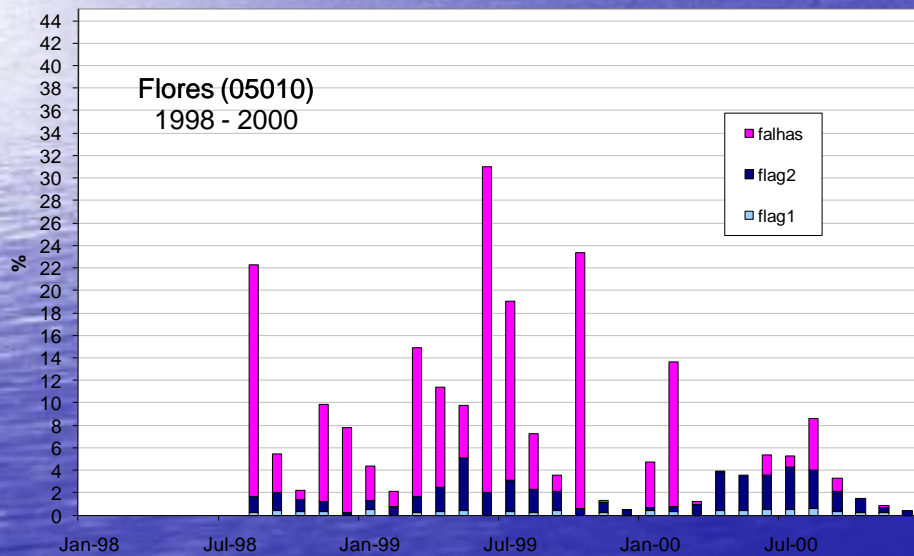
Hourly data outside of the sunrise-sunset period are set to zero.

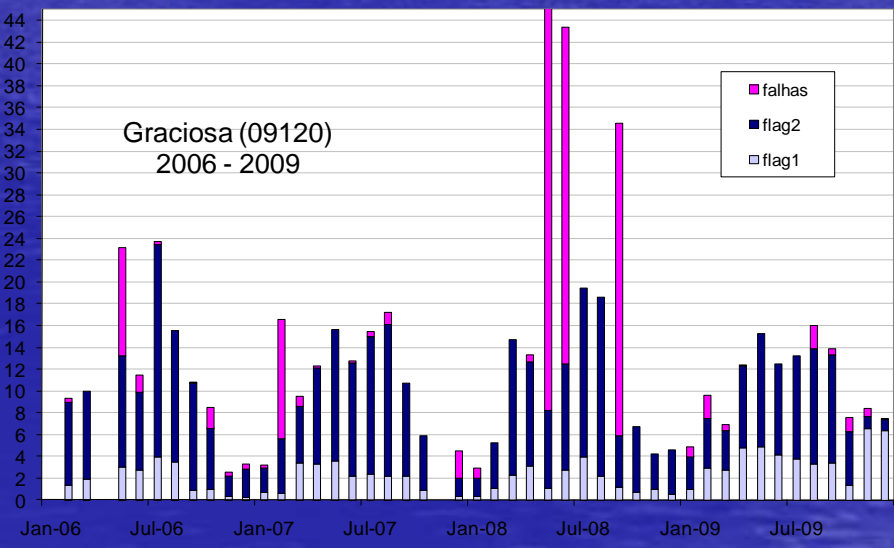
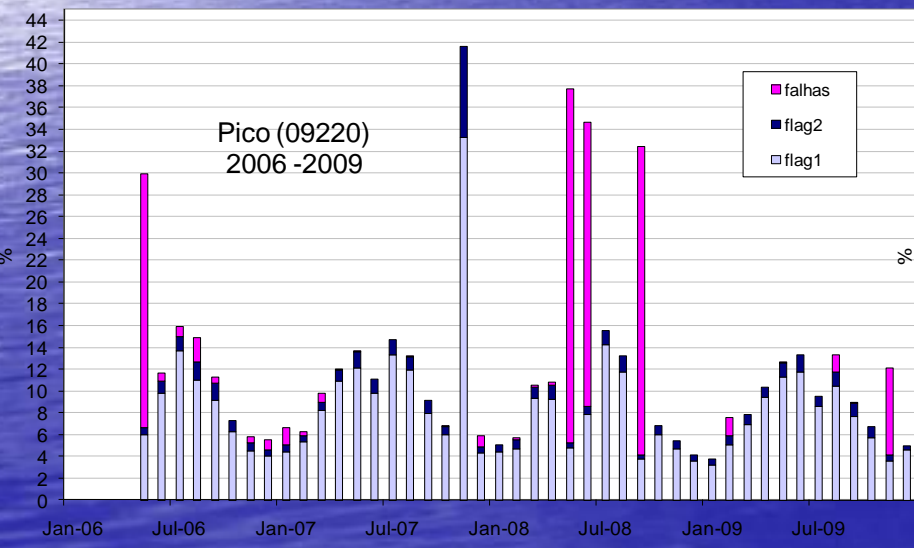
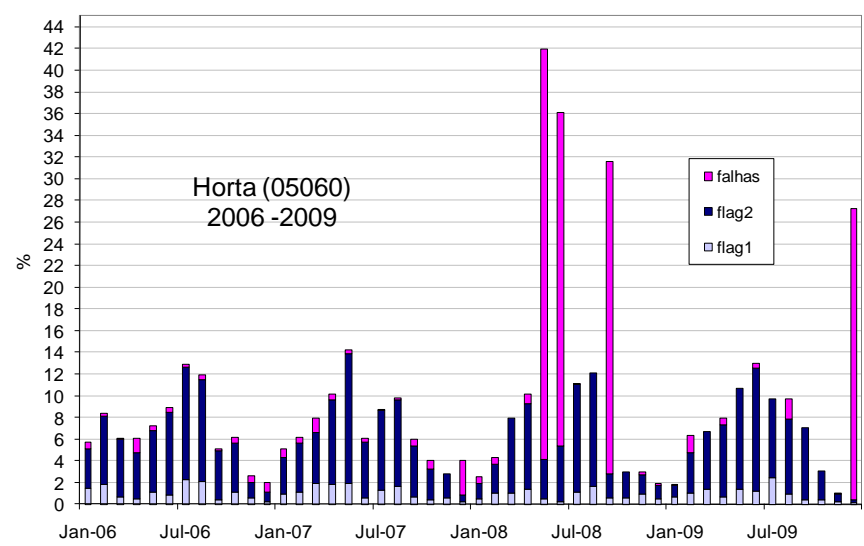
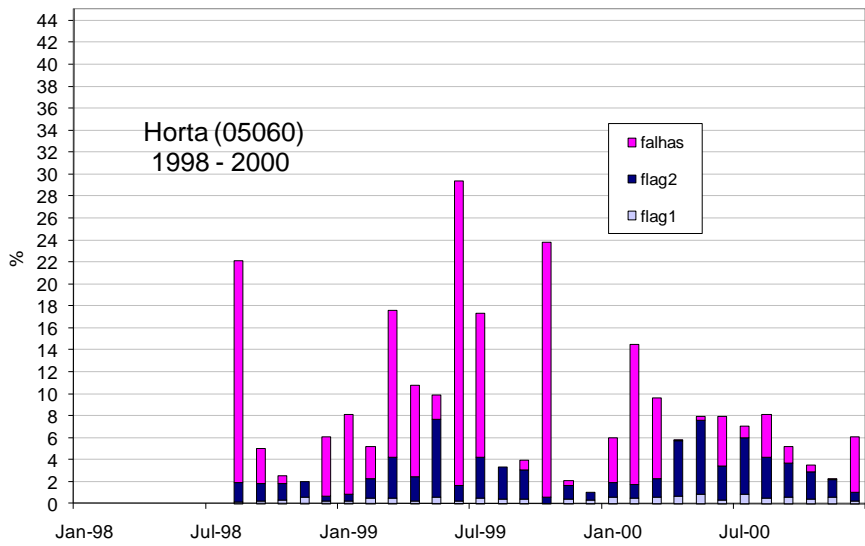
C

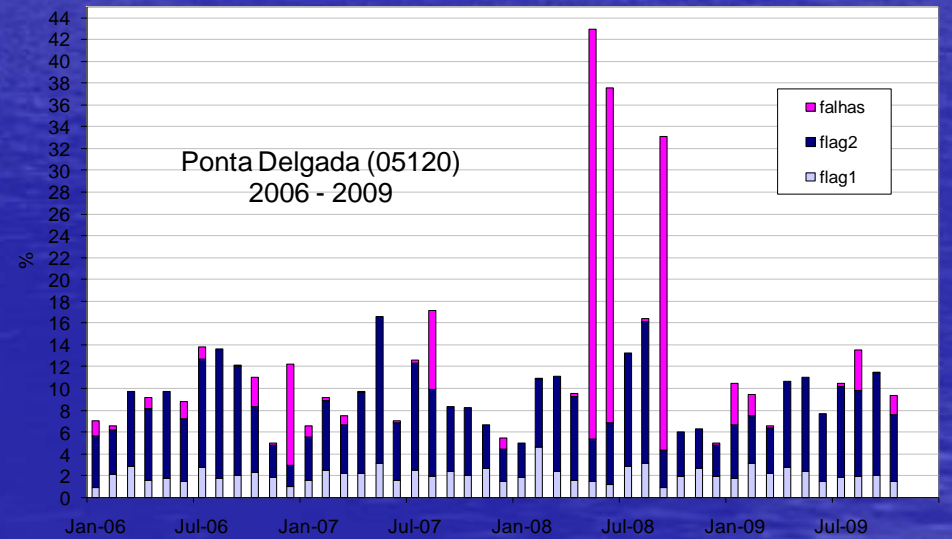
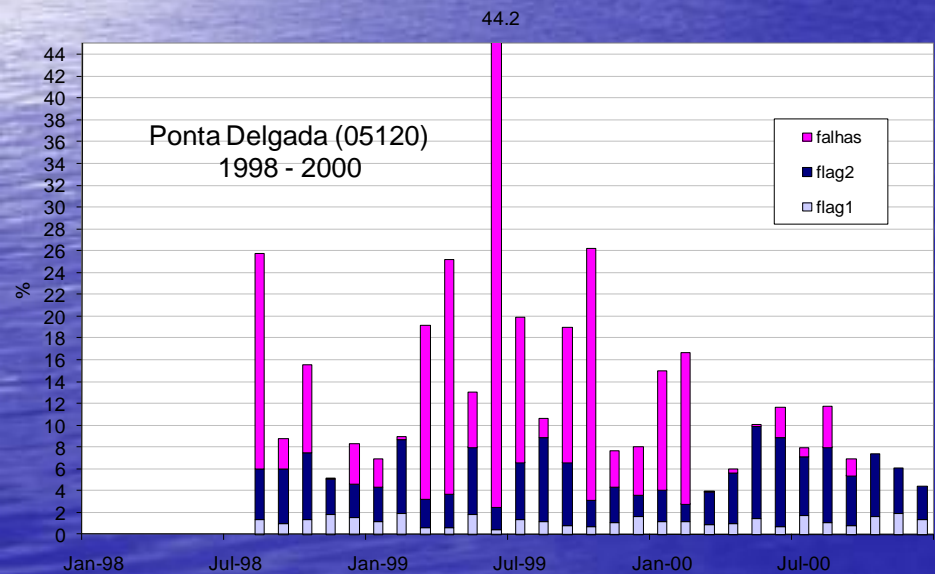
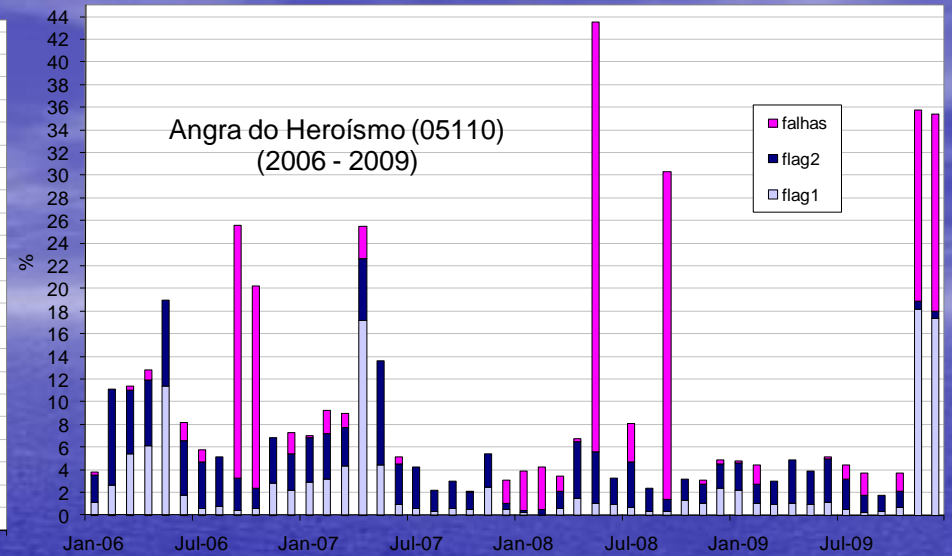
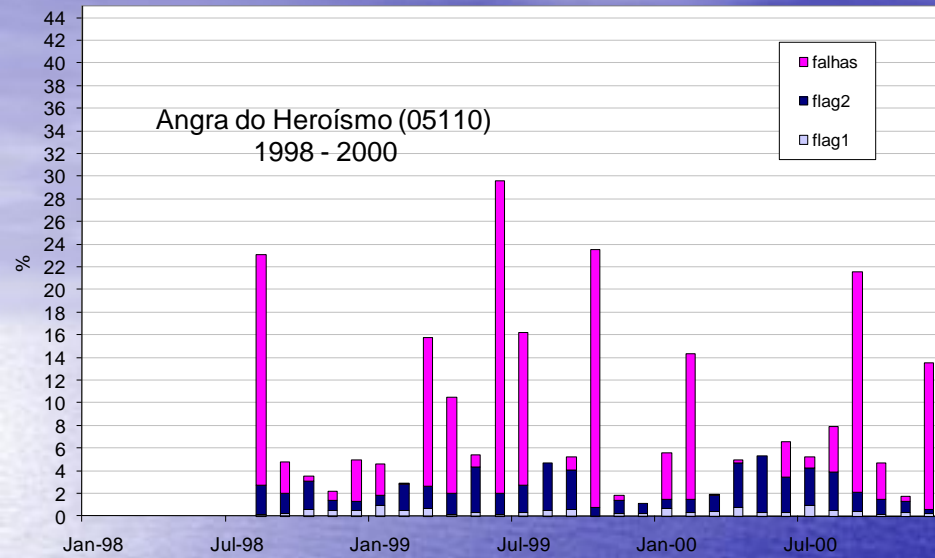
```
if(za.gt.90..or.za.lt.-90.)then
  x(k)=0.
  else if(x(k).eq.0.)then
    x(k)=-1.
  endif
```

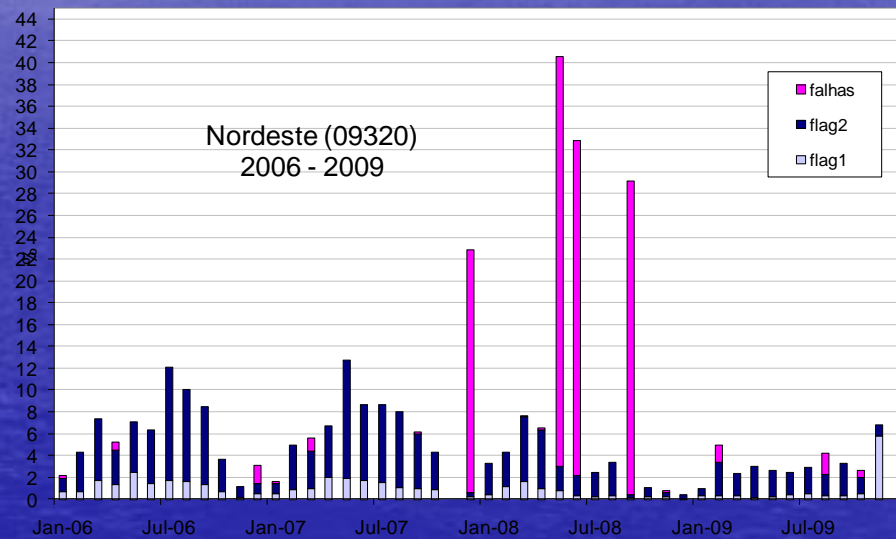
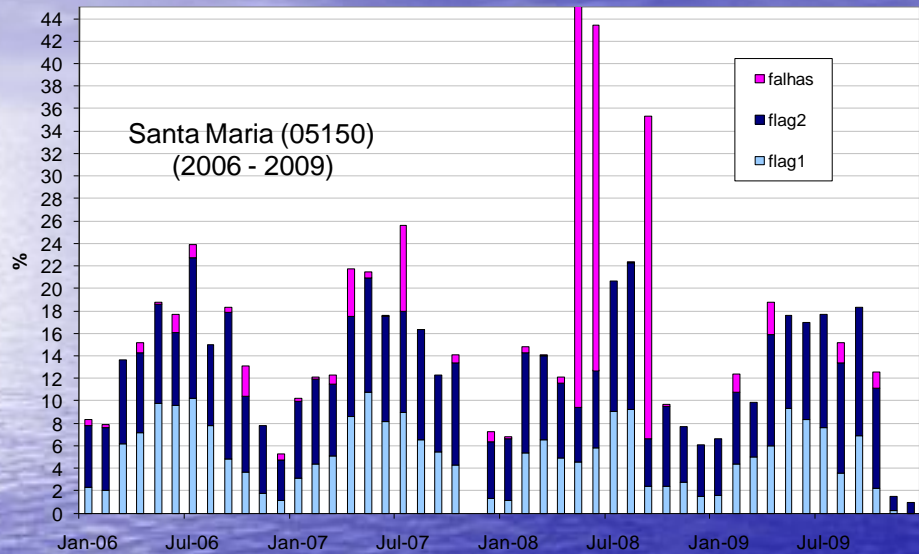
C

Pyrnometers network performance (2000-2009)



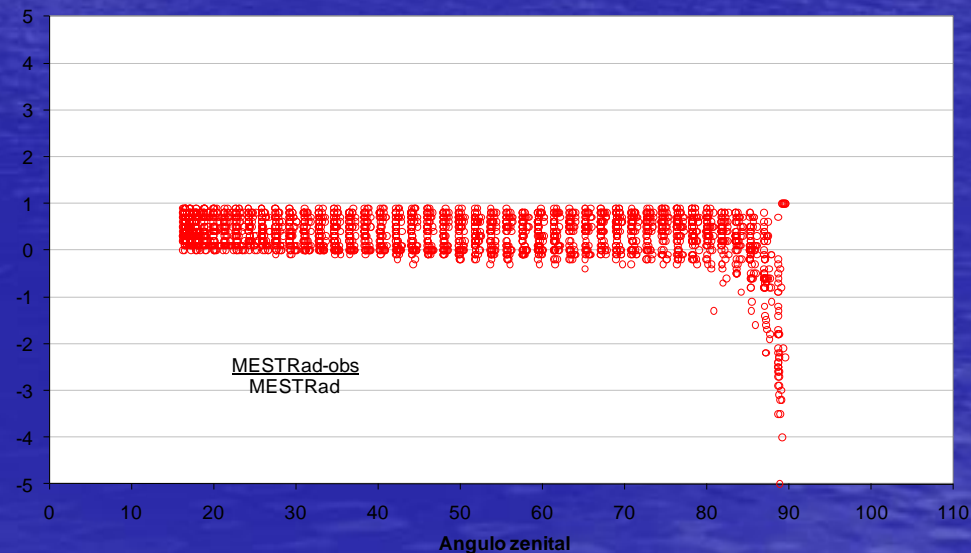
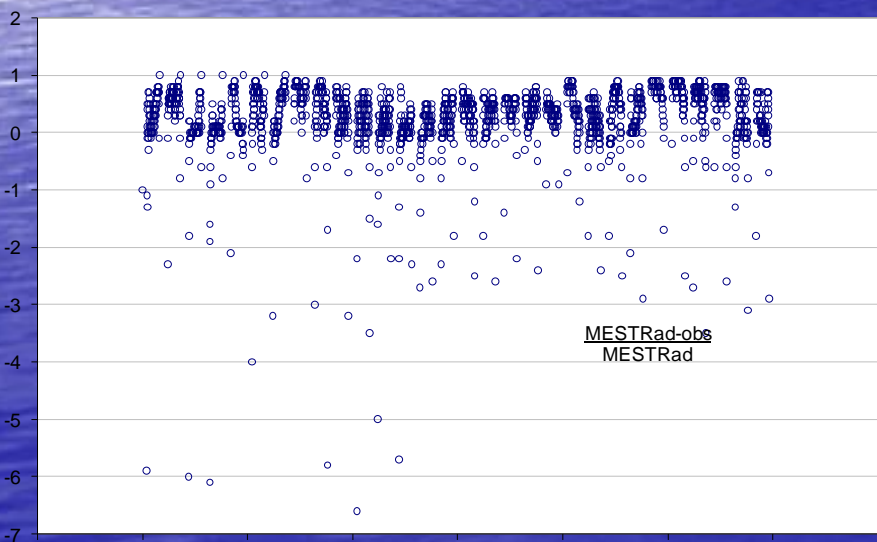
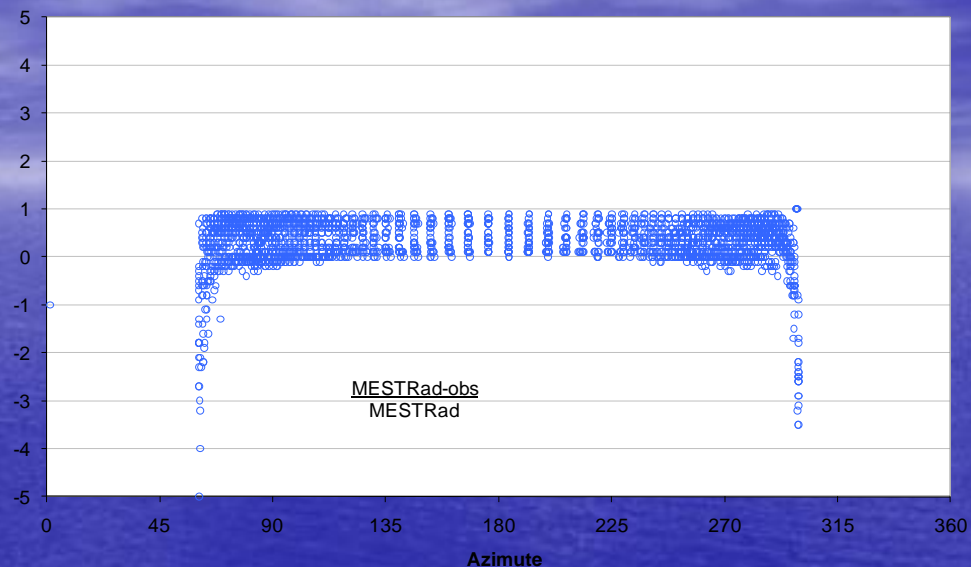






Flores - Global Radiation (10 minutes)

Relative deviation of measurements from model MESTRad

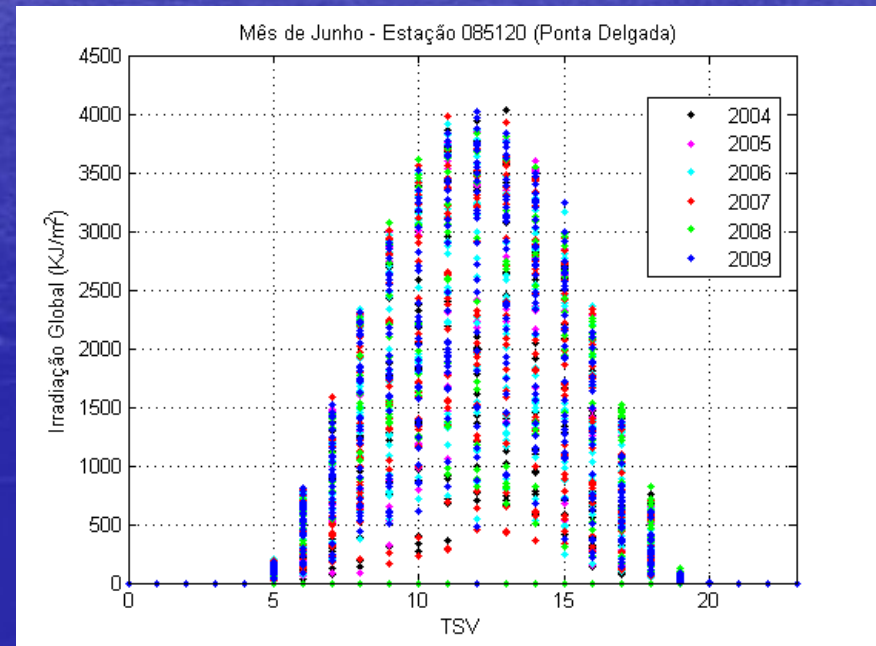
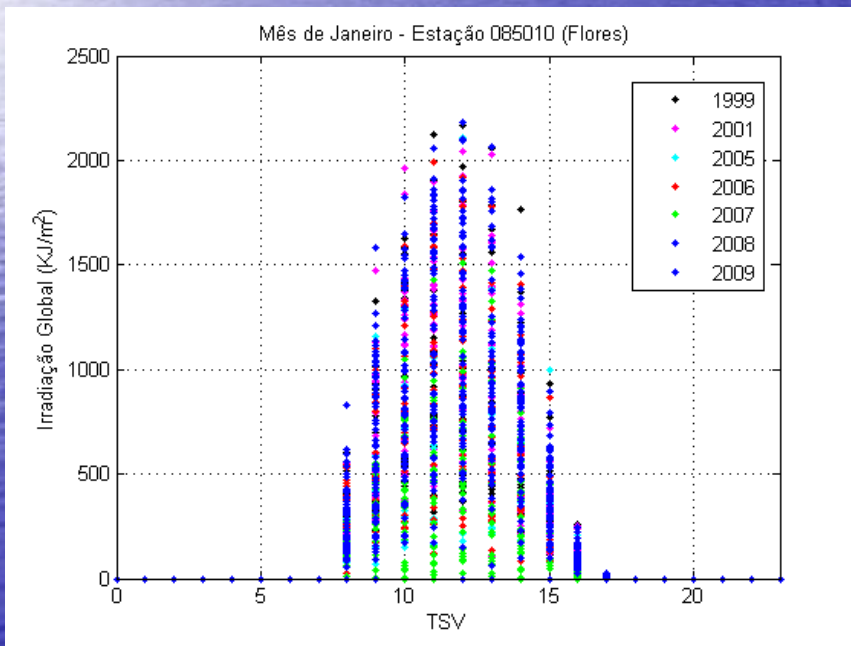


27-5-09 0:00 1-6-09 0:00 6-6-09 0:00 11-6-09 0:00 16-6-09 0:00 21-6-09 0:00 26-6-09 0:00 1-7-09 0:00 6-7-09 0:00

Results (I)

(from 1999-2000 data)

Hourly irradiation (kJ/m²)



Results (II)

(from 1999-2000 data)

Daily global irradiation values tables (Wh/m²)

Daily Global Irradiation values (Wh/m²)

Average, maximum, minimum and number of years

Station ID: 501

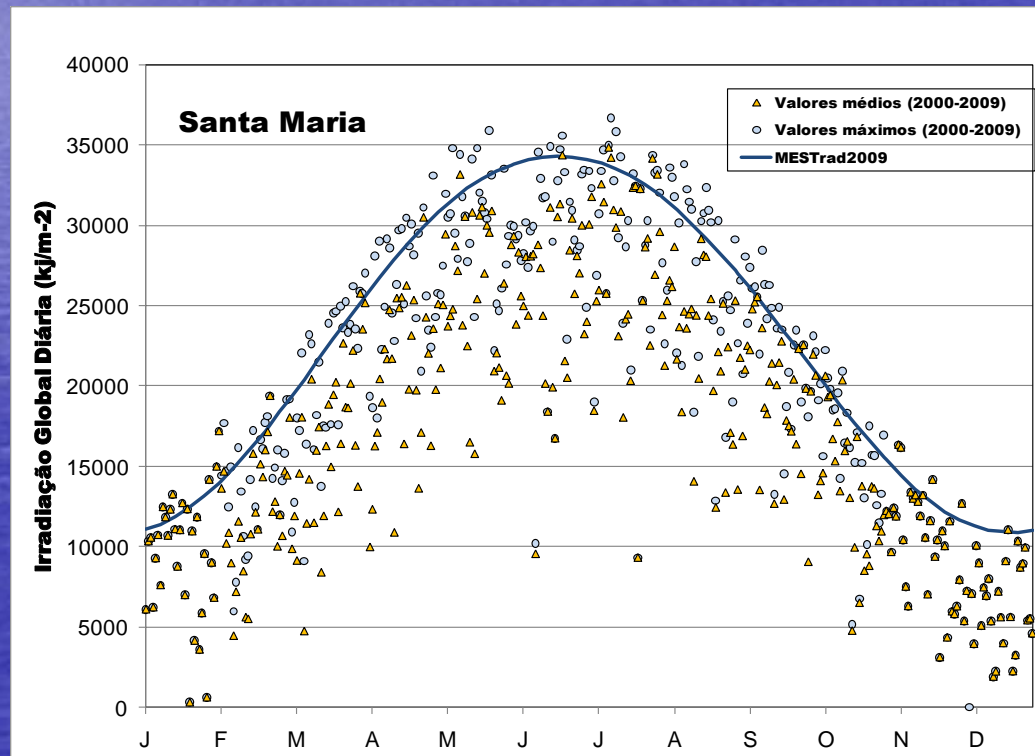
Year range: 1999 - 2009

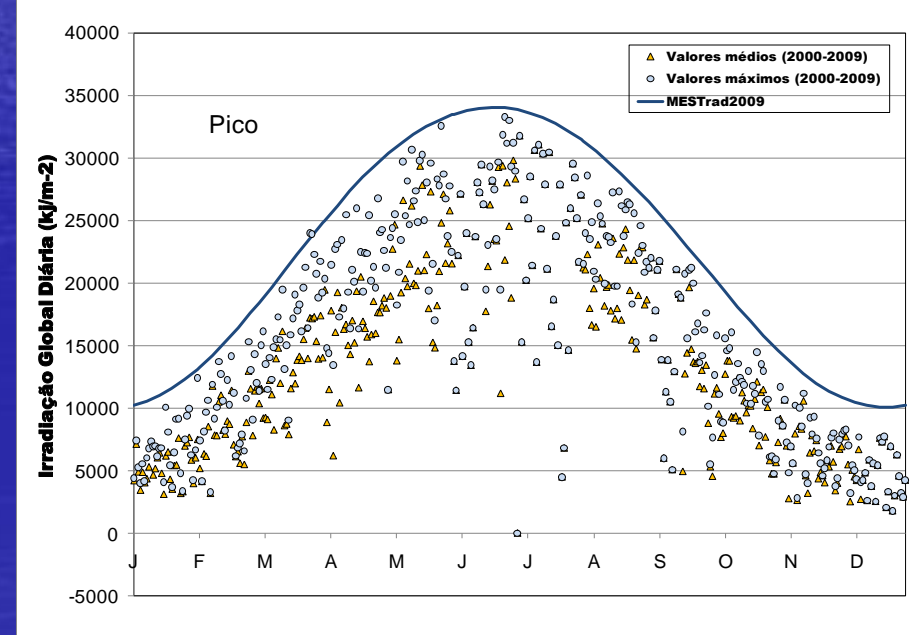
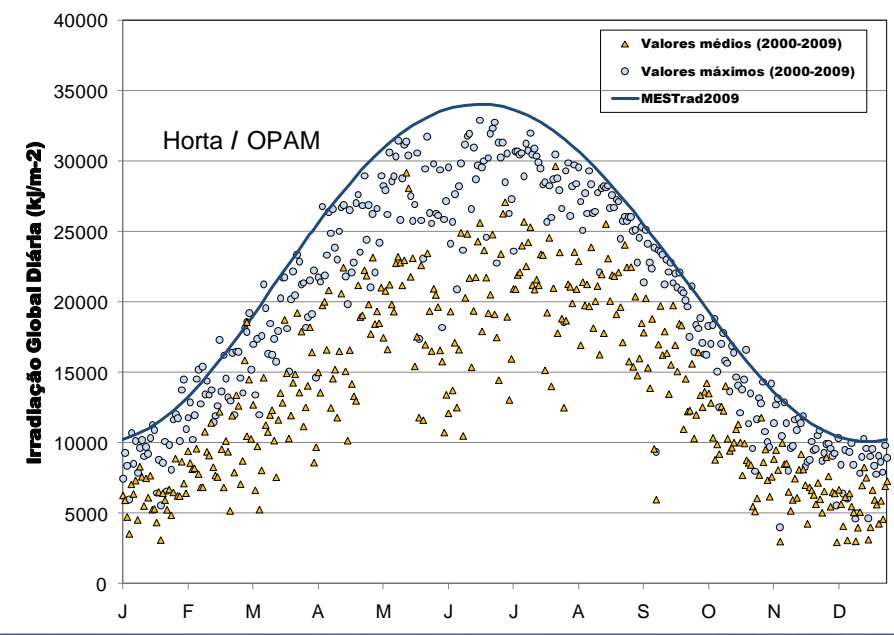
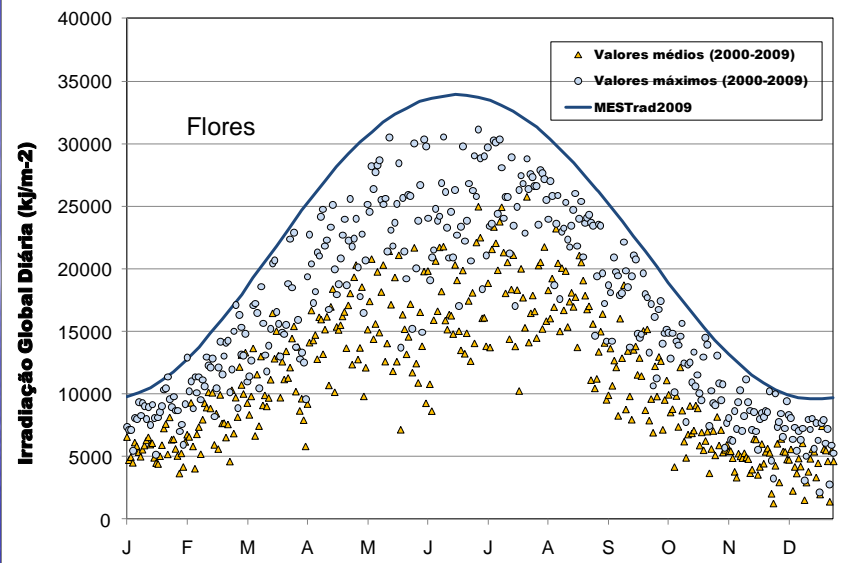
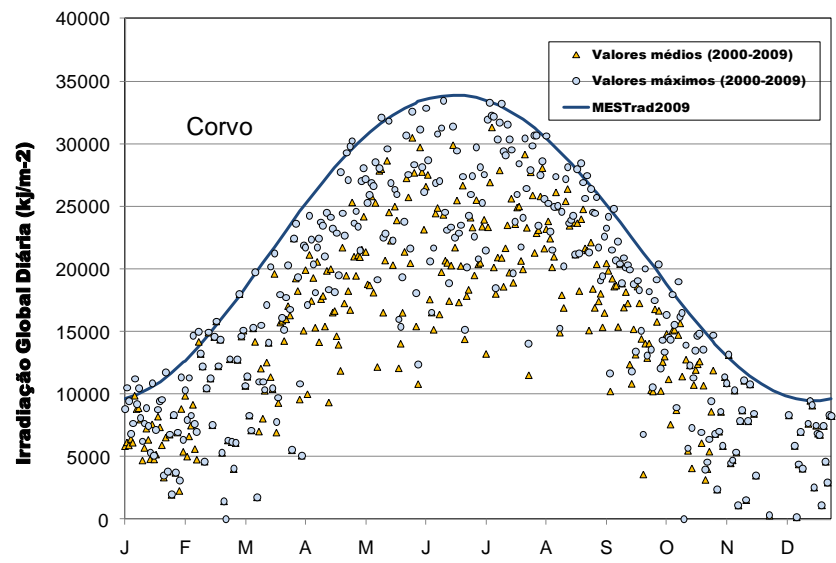
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
01	1786.3	1906.1	3020.5	2860.5	3807.4	6717.3	6939.0	5956.2	4916.7	2976.5	2327.3	1698.6
	2040.7	3581.7	4259.3	3696.8	4941.5	7419.3	8648.6	7561.7	6542.2	3120.7	3627.5	2781.9
	1591.1	891.1	1493.9	1730.9	3134.1	5858.3	6143.9	4196.9	3637.6	2696.7	856.6	801.8
	5	5	4	4	4	3	4	6	4	3	5	4
02	1809.3	1845.2	2977.9	2355.5	5903.7	5073.5	6253.0	5496.7	4168.8	3607.4	1645.4	1682.4
	2301.2	2839.5	3637.4	3478.3	6486.4	7232.4	8007.9	7743.8	6514.1	4654.0	3018.5	2041.9
	1296.6	352.7	1393.1	602.3	4901.0	3546.6	3623.4	4022.1	2916.2	2770.1	331.2	1320.2
	5	3	4	4	3	3	4	5	3	4	3	4

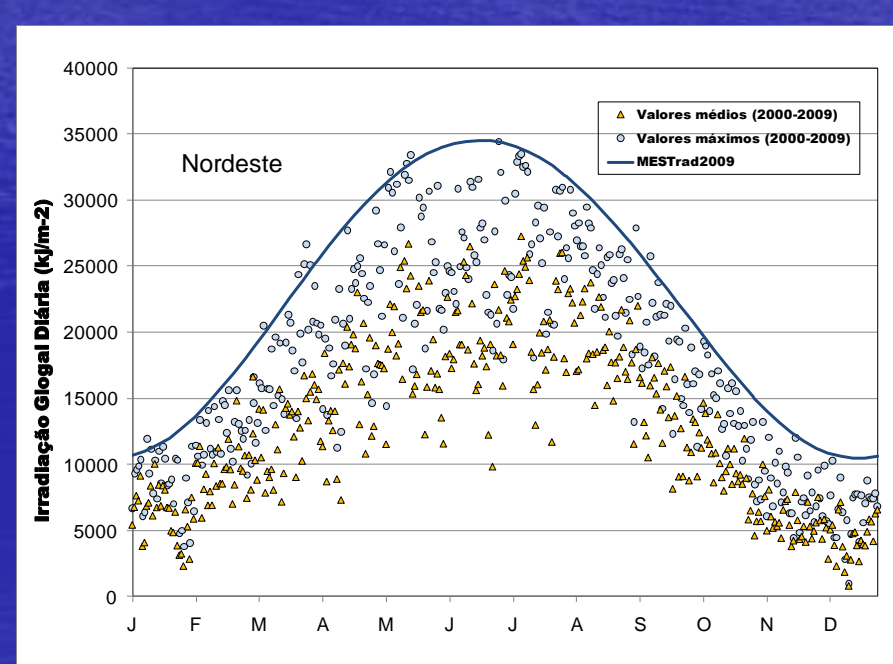
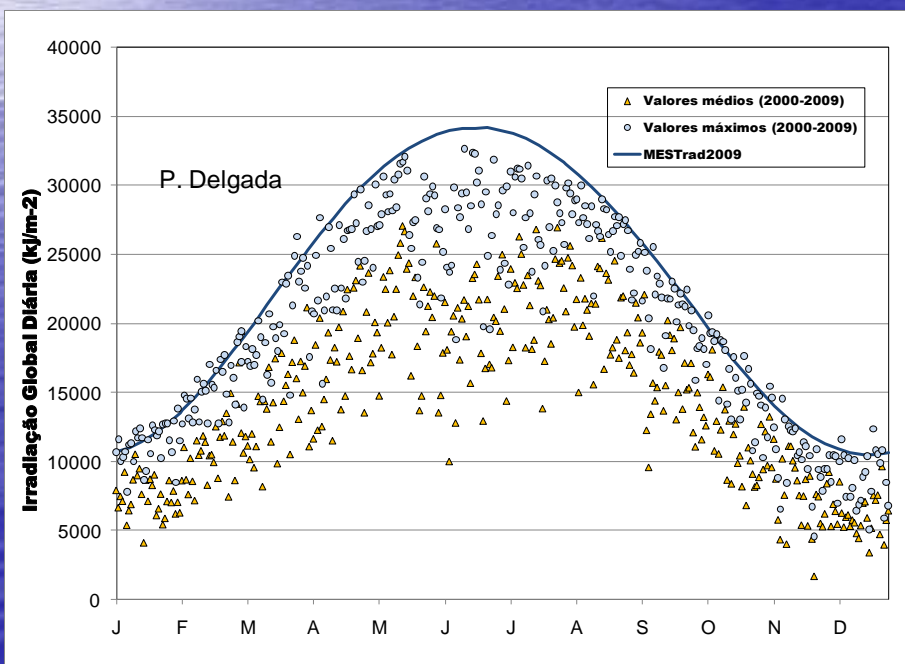
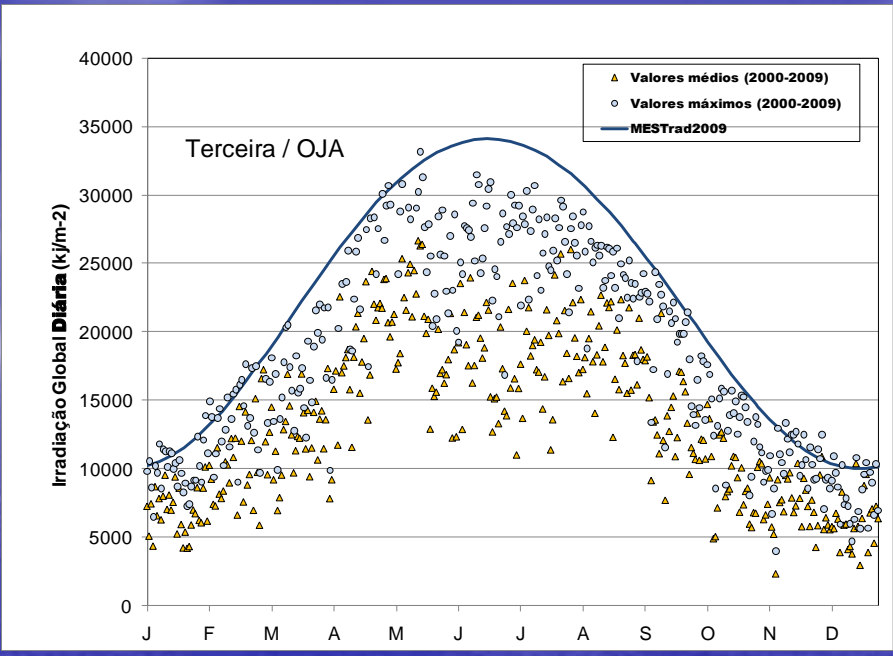
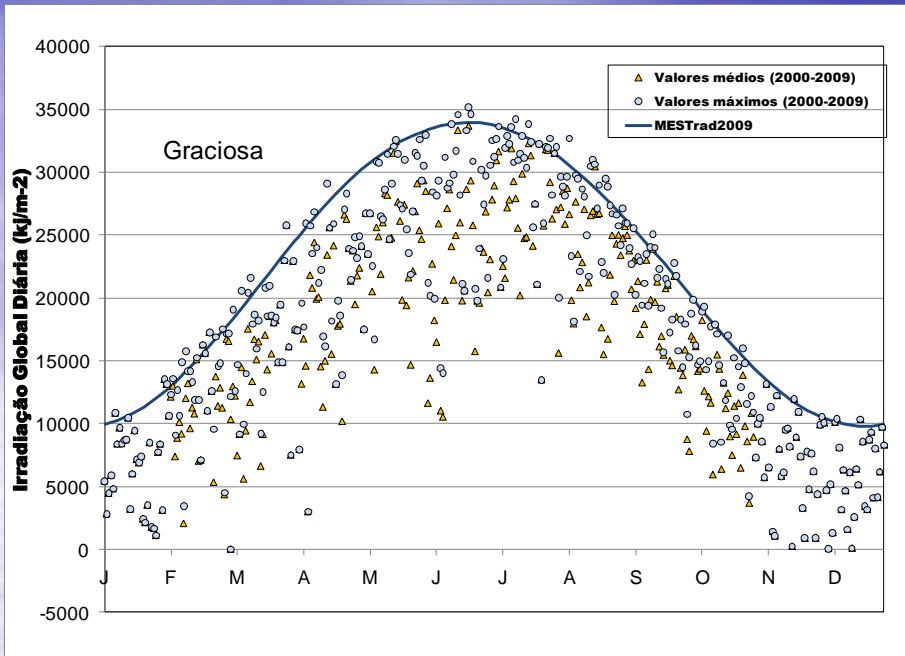
Results (II)

(from 1999-2000 data)

Daily global irradiation (kJ/m²)







Results (III)

(from 1999-2000 data)

Monthly Global Radiation Tables (Wh/m²)

Station: (085060) FAIAL ISL

Global Radiation G in WH.M-2 (WRR)

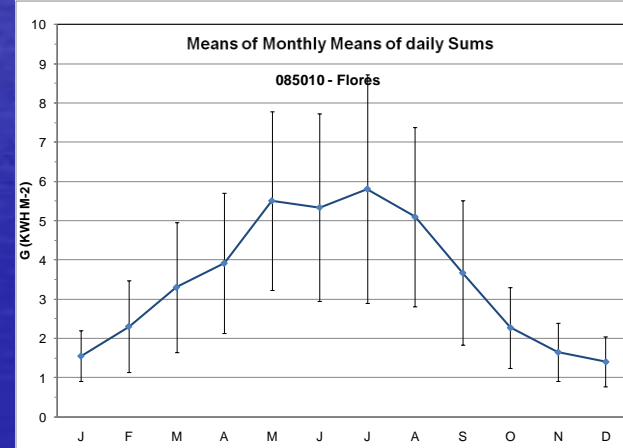
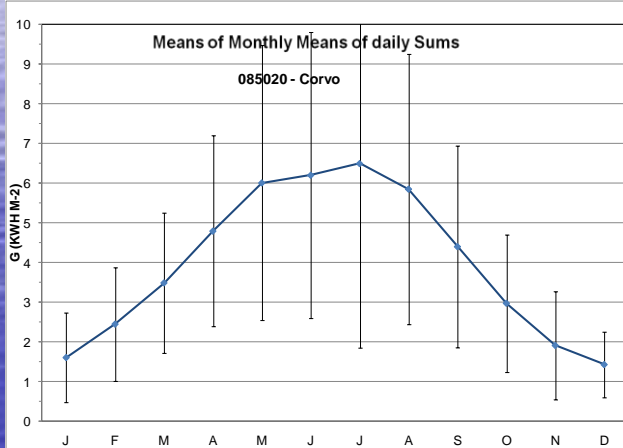
Latitude: 38 31 N Longitude: 28 38 W Altitude: 60 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
G	1865.1	2797.0	3712.3	4519.4	6434.5	5970.2	6437.0	6130.6	4618.6	3090.1	2277.1	1771.3
GSTD	769.6	1403.0	1669.4	2101.8	2644.0	2697.4	3224.0	2747.0	2314.7	1386.8	1021.8	794.0
GMAX	3508.2	4870.8	5865.4	6778.9	8290.6	9060.0	8627.1	8085.1	6756.0	5364.4	3619.5	2786.2
GMIN	450.3	913.0	913.2	1163.5	3792.9	2012.7	2987.6	3114.1	1744.9	692.0	890.7	549.5
N	7	5	6	6	7	6	5	6	5	6	6	6
G0	4585.0	5742.2	8058.3	9696.9	11148.0	11588.8	11192.8	10192.6	8657.8	6269.3	5092.5	4123.0
G/G0	0.407	0.487	0.461	0.466	0.577	0.515	0.575	0.601	0.533	0.493	0.447	0.430

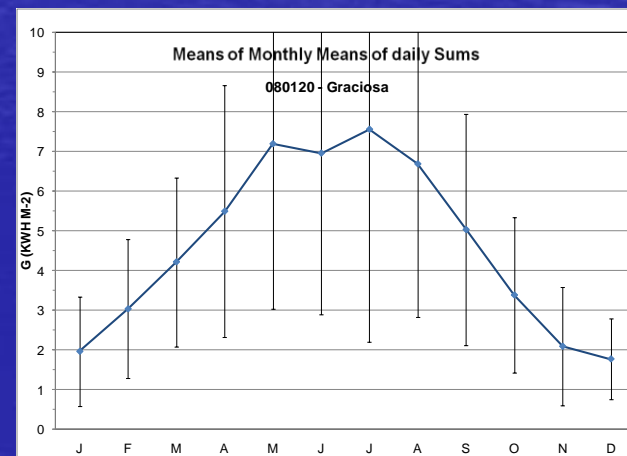
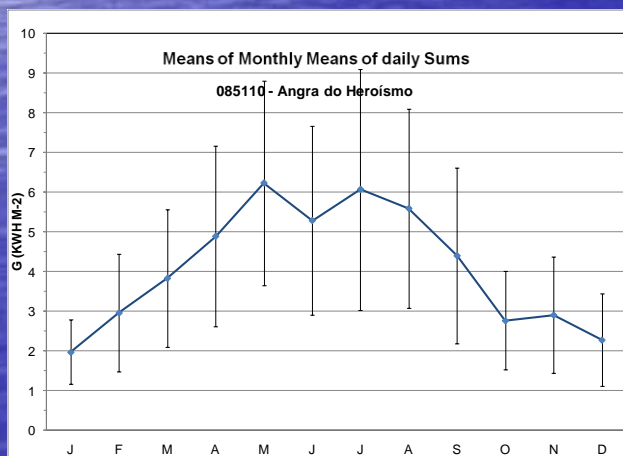
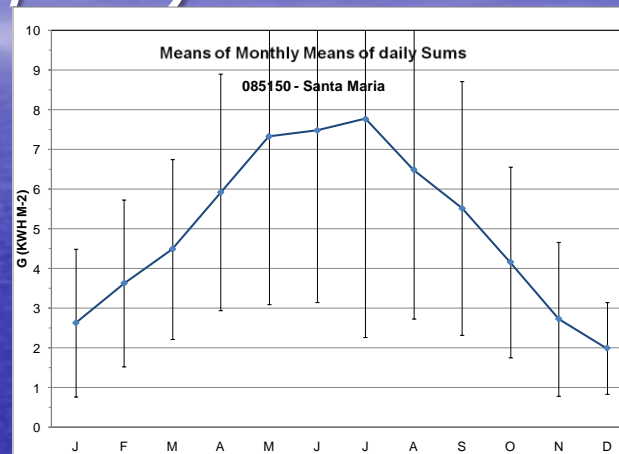
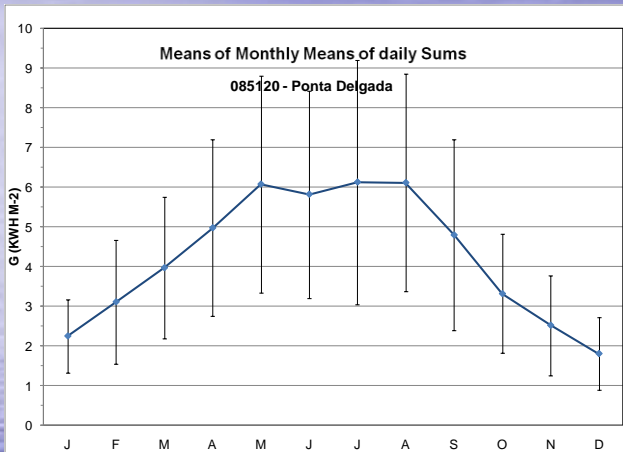
Results (III)

(from 1999-2000 data)

Diagrams of the mean annual course of global radiation (kWh/m²)



Diagrams of the mean annual course of global radiation (kWh/m²)



Results (IV)

(from 1999-2000 data)

Mean annual monthly number of days with daily radiation given thresholds (Wh/m²)

WH M-2	JAN	FEB	MAR	APR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DEC
0	31	28	31	30	31	30	31	31	30	31	30	31
200	31	28	31	30	31	30	31	31	30	31	30	31
400	31	28	31	30	31	30	31	31	30	31	30	31
600	31	28	31	30	31	30	31	31	30	31	30	31
800	31	28	31	30	31	30	31	31	30	31	30	31
1000	31	28	31	30	31	30	31	31	30	31	30	30
1200	31	28	31	30	31	30	31	31	30	31	30	29
1400	31	28	31	30	31	30	31	31	30	31	30	27
1600	30	28	31	30	31	30	31	31	30	31	28	24
1800	26	28	31	30	31	30	31	31	30	31	27	18
2000	23	27	31	30	31	30	31	31	30	31	25	13
2200	14	26	31	30	31	30	31	31	30	31	18	6
2400	9	24	31	30	31	30	31	31	30	27	17	2
2600	5	22	31	30	31	30	31	31	30	25	13	
2800	1	21	30	30	31	30	31	31	30	23	9	
3000		16	27	30	31	30	31	31	30	21	7	
3200		12	25	28	31	30	31	31	30	20	5	
3400		7	23	28	31	30	31	31	28	17	4	

Thanks for your attention

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