ON-LINE SOLAR RADIATION MONITORING SYSTEM, IN CLUJ NAPOCA, ROMANIA

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Introduction

☼Sun can be considered ***a huge source of free energy***, being also the unique energy source able to entertain the life on Earth.

☼The life of the Sun is estimated at the following 4-5 billions of years, this being an enough reason to exploit the solar energy potential.

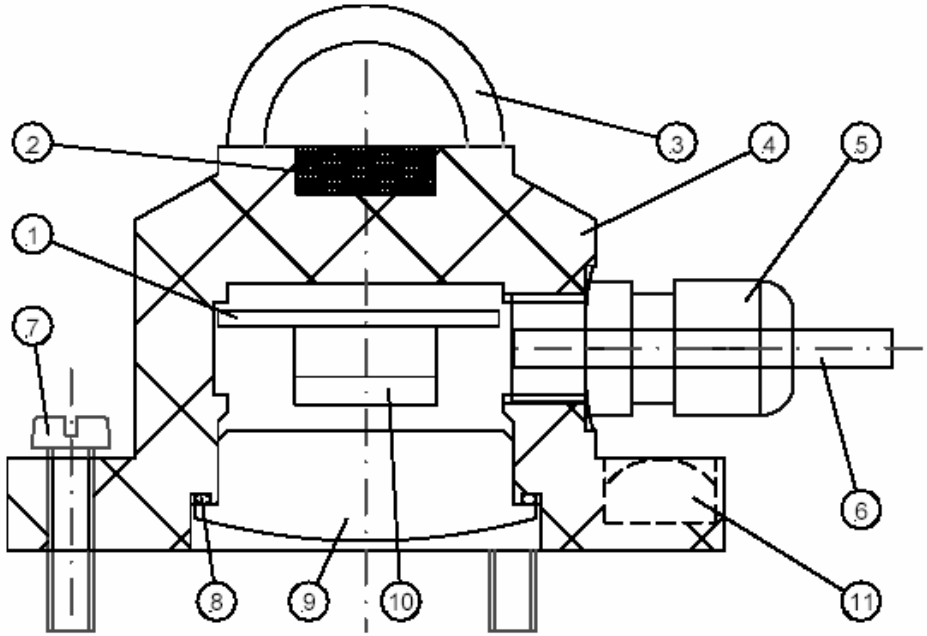
☼***The incoming solar radiant energy***, per square meter, at the outside limit of the earth atmosphere, named solar constant, determined by satellite technologies measurements, is reported in range of 1350…1366 W/m^2.

Introduction

☼From the outside limit of the atmosphere, until the Earth surface, ***the intensity of the solar radiation is decreased*** by several known effects (reflection, dispersion, absorption, etc.)

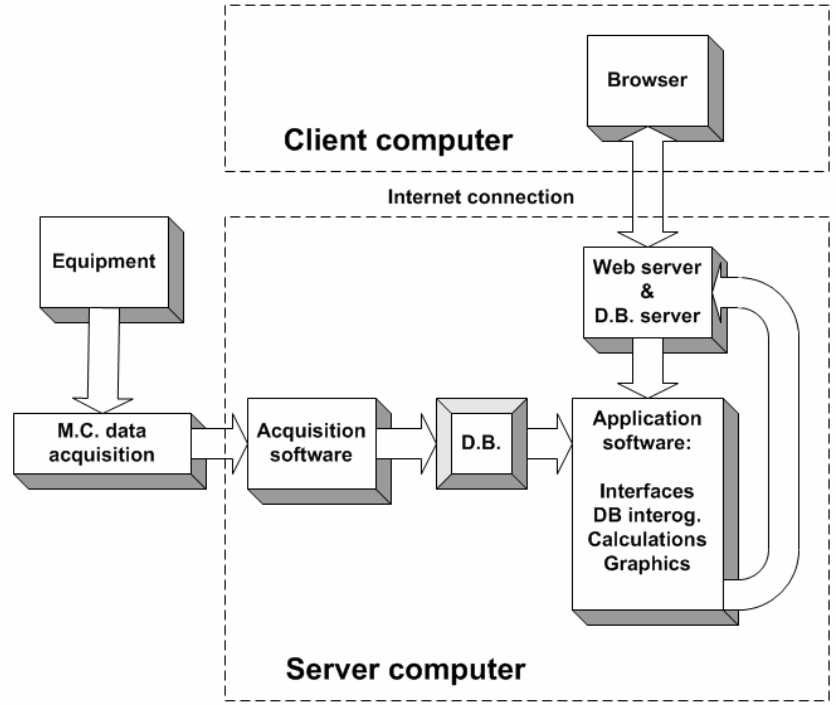
☼For ***technical applications***, it is important to know the solar radiation potential, at the Earth surface, and this kind of radiation is measured on-line, by a solar radiation monitoring system, in Cluj-Napoca.

Sensor for solar radiation measurement (pyranometer)



1 - printed circuit board; 2 - solar radiation sensor;
3 - glass dome; 4 - body;
5 - electrical cable connector;
6 - electrical cable;
7 - screw for horizontal level fixing;
8 - fixings; 9 - access for cable connection;
10 - screwed electrical connector; 11 - water babble.

Working principle of a (pyranometer)



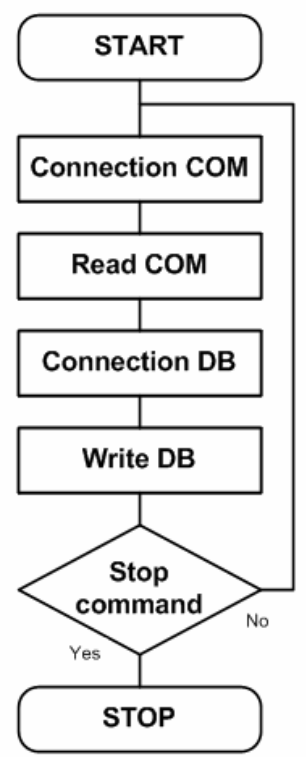
Working principle scheme of the data acquisition and monitoring system

Principle scheme of the data acquisition system using a microcontroller

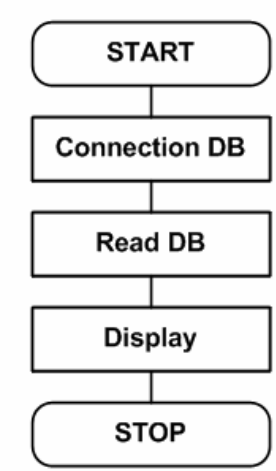
Methods

Software components of the monitoring application:

☼Storing the values of the solar radiation intensities into a database;
☼Multiple criteria selection of the stored data;
☼Display of the data on a web based virtual monitoring panel;
☼Graphical representation of the selected database stored information.



Principle flow chart of the
“Acquisition software” component



Principle flow chart of the
“Database interrogation” component

Solar radiation monitoring

Location: Cluj Napoca - Romania
Latitude: N 46° 47,758'
Longitude: E 23° 37,563'

Last recorded values:

Time yyyy-mm-dd hh:mm:ss	Total radiation [W/m^2]	Diffuse radiation [W/m^2]	Direct radiation [W/m^2]
2007-12-26 14:52:08	80	44	36

Recorded values (for selected period):

	Year	Month	Day	Hour	Radiation type	Time step - minutes	Selected records	
From:	2007	12	26	14	All	15	100	list recorded values
To:	2007	12	26	15				

Recorded values (for selected hour):

Year	Month	Day	Hour	Radiation type	Time step - minutes	Selected records	
2007	12	26	14	All	5	100	list recorded values

Recorded values (for selected day):

Year	Month	Day	Radiation type	Time step - minutes	Selected records	
2007	12	26	All	20	100	list recorded values

Recorded values (for selected month):

Year	Month	Radiation type	Time step - minutes	Selected records	
2007	12	All	30	100	list recorded values

Recorded values (for selected year):

Year	Radiation type	Time step - minutes	Selected records	
2007	All	60	100	list recorded values

Snapshoot of the monitoring panel

Results and Discussions

Solar radiation monitoring

Location: Cluj Napoca - Romania

home

Recorded values:

Year: 2007 Month: 8 Day: 17 Hour: 13 - 14
Time step: 10 minutes

Time yyyy-mm-dd hh:mm:ss	Total radiation [W/m^2]	Diffuse radiation [W/m^2]	Direct radiation [W/m^2]
2007-08-17 13:00:28	871	55	816
2007-08-17 13:10:32	856	53	803
2007-08-17 13:20:36	865	55	810
2007-08-17 13:30:39	801	53	748
2007-08-17 13:40:43	842	58	784
2007-08-17 13:50:47	843	60	783

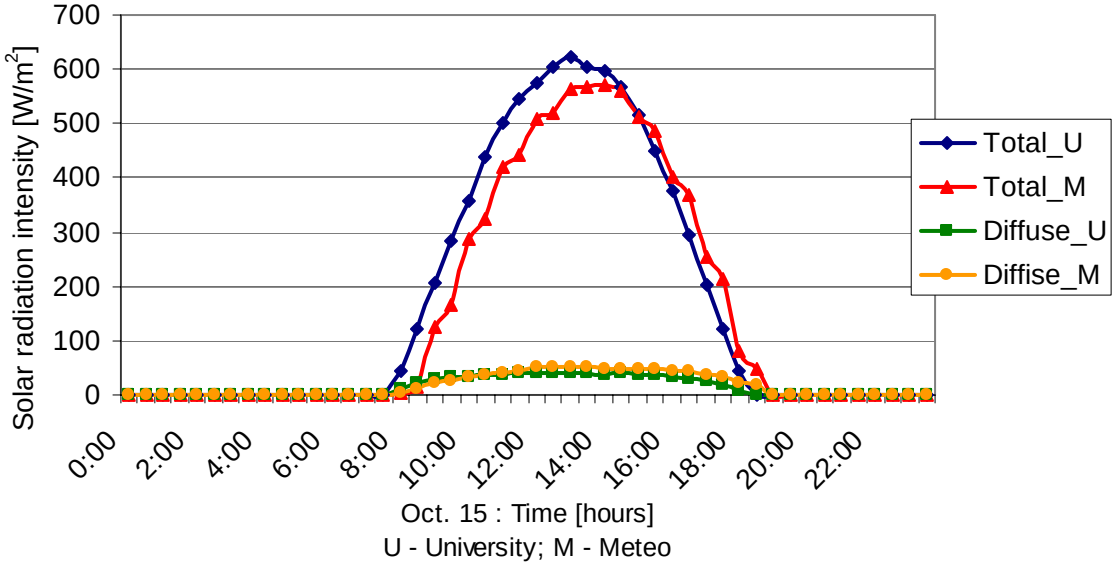
Values recorded for the solar radiation intensity

Average values for October 17, 2007;

☼total radiation for *sunshine duration* is **441 W/m^2**;
☼total radiation for *24 hours* is **163 W/m^2**;
☼diffuse radiation for *sunshine duration* is **37 W/m^2**;
☼diffuse radiation for *24 hours* is **14 W/m^2**;
☼direct radiation for *sunshine duration* is **403 W/m^2**;
☼direct radiation for *24 hours* is **148 W/m^2**;
☼sunshine duration: 8 h 31 min 36 sec ± 50 sec (from 08:45:44 to 17:17:20)

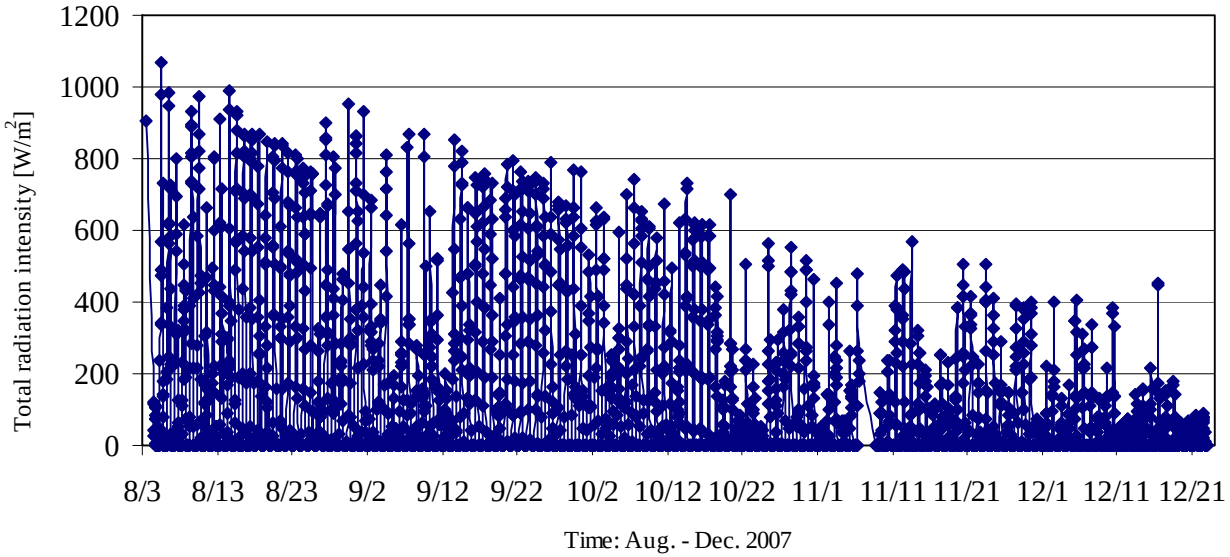
Solar radiation components:
☼Global solar radiation: **3887 Wh/m^2**;
☼Diffuse solar radiation: **453 Wh/m^2**;
☼Direct solar radiation: **3525 Wh/m^2**.

Comparison of two measurements



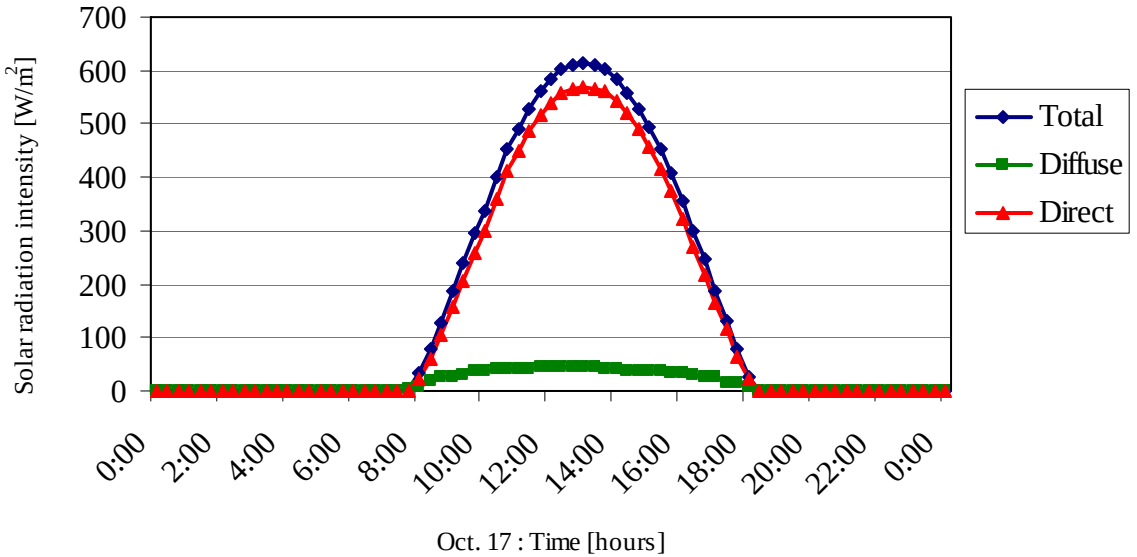
In order to check if it exist a significant difference between our measurements and those provided by Meteorological Station, for October 15, 2007, we applied the nonparametric Wilcoxon Matched Pairs Test by using the Statistica v.6.0 software. Forty-eight measurements were not null and entered into the comparison. A T value of 84 and a Z value of 1.886 were obtained.

The p-level resulting from the Wilcoxon test was 0.059, being higher than 0.05, thus at 5% level of significance is no difference between our measurements and measurements at meteorological station.



Variation of the total solar radiation intensity, in the period August - December 2007

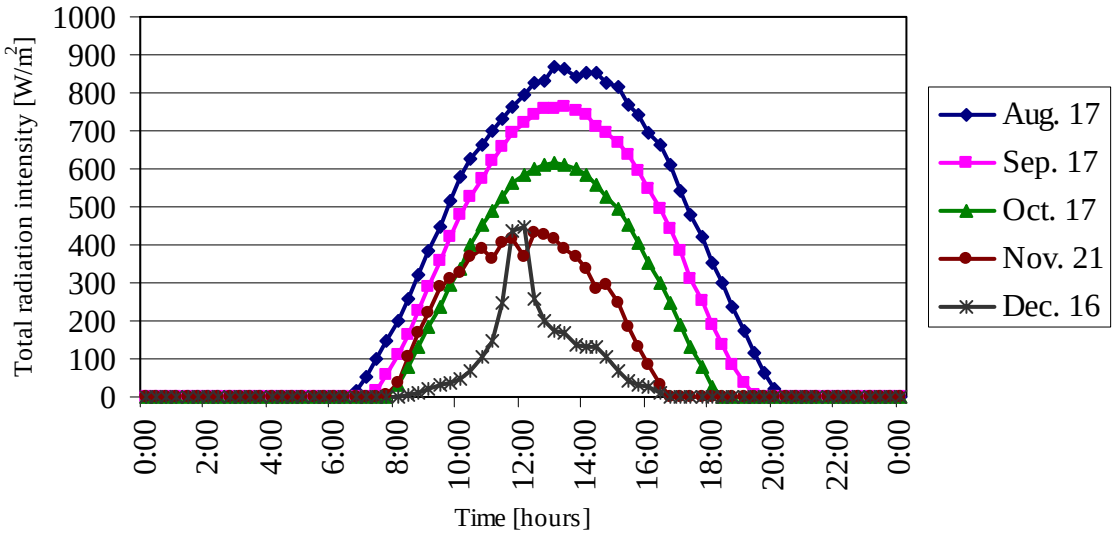
It can be observed the descendent trend of the recorded values of the total solar radiation intensity



Values of the total, diffuse, and direct solar radiation intensities for October 17

The shape of this curves, seems to obey with the prediction model for the solar radiation

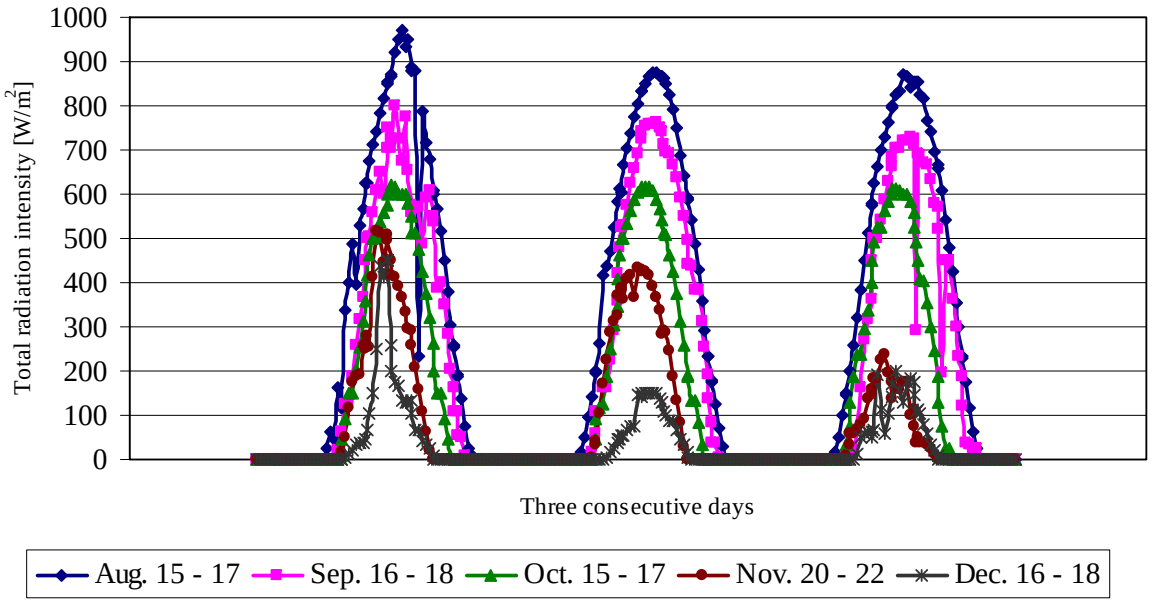
Comparative values for the total solar radiation intensities



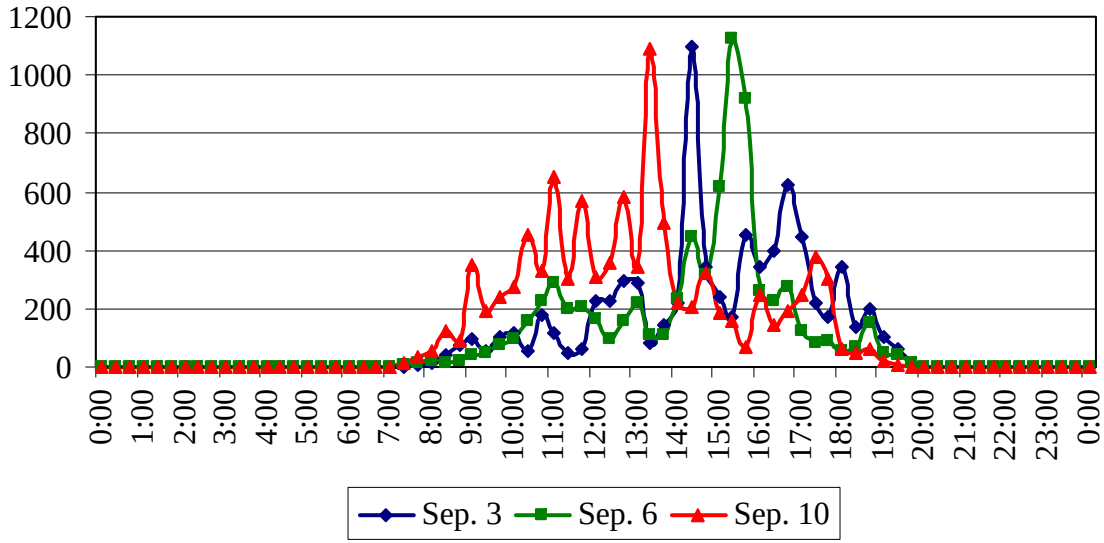
The choice of sunny days in November and December was difficult because they were very cloudy.

It can be observed that the curves corresponding to the selected days of November and December are translated to the left, comparing to the other three curves. This fact is due to the local winter time which started on October 28. On the figure it was kept the local time, as it was recorded in the database.

It can be easily observed that the total solar radiation intensity and the length of the day are continuously decreasing in the period August - December, as expected.

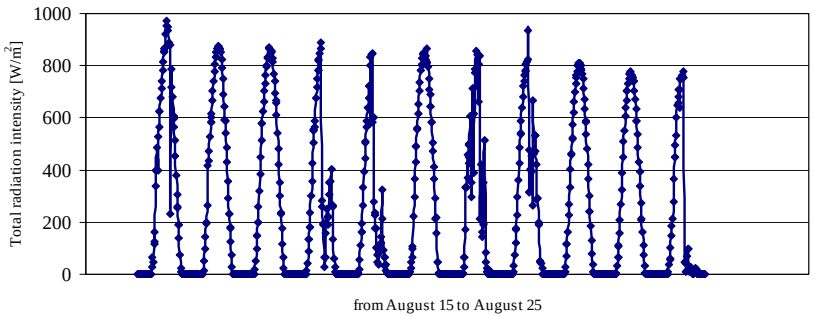


Evolution of the total solar radiation intensities, in three consecutives days

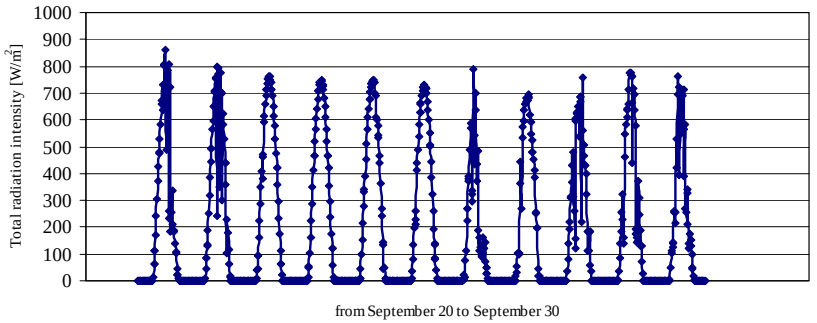


Three days in September, with high values of the total solar radiation intensity

Figure is highlighting how in three days of September, were reached high values of the total solar radiation intensity (more than 1000 W/m^2).
It can be observed that in each of the selected days, the morning was cloudy, and with probable rain periods, which could clean the atmosphere. In these conditions, if sun appeared at noon, the values of the total solar radiation intensity were high.



Evolution of the total solar radiation intensity, for a succession of 10 days in August



Evolution of the total solar radiation intensity, for a succession of 10 days in September

Conclusions

The presented solar monitoring system is representing an original, complex and useful hardware and software tool, able to offer all the needed information, to evaluate the local potential of the solar energy, to be used in thermal collectors or in PV panels.
The preliminary results obtained with the presented solar radiation monitoring system, proves that important and relevant information can be obtained by its use. For instance the averaged values of global, diffuse and direct solar radiation, can be computed for any selected period of time, together with the value of the sunshine durations.

Conclusions

By applying a Wilcoxon Matched Pairs Test between our measurements, and the measurements provided by the local meteorological station, it was proved, that there are no significant differences between the two measurements. It means that the data provided by our solar radiation monitoring system can be used in future investigations with a high level of trust.

The recorded data are correlated with the expected trend of the total, diffuse and direct solar radiation intensity.

A long time monitoring, will provide very useful data for log term local strategies for the use of the solar energy. Equally it will allow the developing of a simulation software tool to predict the solar radiation intensities, for the city of Cluj-Napoca.