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Observing And Measuring Sunspots In VIS And NIR Regions

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Abstract

This study is dedicated for observing and studying sunspots in the visible and near infrared regions. Visible and near infrared CCD solar imaging system employing 5 inch reflecting telescope is used. The obtained visible and near infrared solar images during the period 01-31, January 2007, and their measurements are presented and compared.

Images obtained with the wavelength 850 nm show sunspot groups of sharp contrast compared with the visible spectrum images. This leads to larger values of solar activity measurements R and larger daily total sunspots groups areas . According to McIntosh sunspot classification the frequency of occurrence among the allowed types of sunspot groups is the same in the both regions. However , the adoption of wavelength 850 nm is recommended for reliable sunspot observation and calculation .

Keywords : Sun; Sunspot measurements

رصد وقياس البقع الشمسية في المنطقتين المرئية وتحت الحمراء القريبة

الخلاصة

كرست هذه الدراسة لرصد ودراسة البقع الشمسية في المنطقتين المرئية وتحت الحمراء القريبة 0 تم استخدام منظومة تصوير CCD شمسية تعمل فى المنطقة المرئية والمنطقة تحت الحمراء القريبة باستعمال تلسكوب عاكس بقطر 5 انج 0تم عرض الصور الشمسية المستحصلة في المنطقة المرئية والمنطقة تحت الحمراء القريبة الملتقطة خلال الفترة من 1 لغاية 31 كانون الاول 2007 والحسابات المتعلقة بها وتمت المقارنة بينهما 0اظهرت الصور الملتقطة عند الطول الموجي 850 نانومتر ان مجاميع البقع الشمسية تمتلك تباينا حادا بالمقارنة مع الصور الملتقطة عند الطيف المرئى.تؤدي هذه الملاحظة الى تسجيل قيم كبيرة لقياسات النشاط الشمسي ولمساحات مجاميع البقع الشمسية الكلية اليومية. يبقى تعاقب ظهور انواع مجاميع البقع الشمسية ضمن تصنيف ماكنتوش للبقع الشمسية هو نفسه لكلا المنطقتين. توصى الدراسة باعتماد الطول الموجي 850 نانومتر كتطبيق عملي لتحقيق رصد أو إجراء حسابات موثوق بها للبقع الشمسية .

1. Introduction

Observation of the Sun's surface, also called the photosphere with special filter usually shows the presence of dark spots on the Sun's surface. Sunspot vary in size from 2,000km to 100,000 km. Larger spots consist typically of an umbra (dark core) surrounded by a penumbra (bright grey area). Sunspots have a lifetime from as little as a few hours to many weeks.

Sunspots are changing with time, their progression across the solar disk revealing the Sun's rotation. The relation period of the Sun is a function

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of latitude, varying from 25 to 34 days, the period increasing as higher solar latitude are reached. When a spot approaches the solar limb, it appears as a cavity on the solar surface [1].

Because sunlight is so bright, it can be filtered down to a narrow band of color emitted by some specific atom ("spectral line") and still have enough brightness left to observe the Sun in detail. Pictures taken of the Sun in such filtered light show much more detail than pictures taken in plain sunlight, and contain additional information; for instance, the magnetic nature of sunspots was found by observing them in spectral lines sensitive to magnetic fields.

Certain spectral lines are a vary range of colors at which an object such as the Sun shines less brightly or brighter than at nearby colors (e.g. the red line of hydrogen and Ca II line in one ionized calcium (at 849.5, 854.2, and 866.2 nm) these lines particularly useful, because they come from high levels in the Sun's atmosphere. When the Sun is observed in the light of such lines, a sudden brightening is now and then seen near the sunspots, at times expanding tens of thousand of kilometers in a matter of minutes. Such abrupt events were named solar flares, and what made them especially interesting was that occasionally, after a prominent flare, a magnetic storm would erupt on Earth. [2]

Most works, aimed at observing and calculation of sunspots, have dealt with the visible spectrum, utilizing either conventional photographic images or modern CCDs digital images. Several works that have studied the characteristic of sunspots with the visible spectrum are reported [3-7].

However, no works on studying the characteristics of sunspots in near infrared region have been mentioned .

This work is aimed at observing the sunspots in the visible and near infrared wavelengths and carrying out measurements of sunspots in both spectra.

Results are compared and showed that 850 nm images reveal sharp high contrast sunspots.

2. Observations

Solar images that have been obtained in this work during the period 01-31 January, 2007 both visible and NIR region are illustrated in Fig.1. Sunspot groups, AR(933), AR(935), AR(940), and AR(941) are shown.

The observing system used here is a CCD imaging arrangements employing 5 inch Cassegrain telescope objective (an objective that is adequate for the current observation and measurements although larger objective is recommended for examining detailed sunspots fine structures) assembled for the purpose of making this work possible.

3. Data Analysis

Table 1, summarizes the results of data analysis for the CCD solar imaging system. Data for each day shown in this table are divided into two parts.

The first part (part i) explains the data for the active regions in VIS. The second part (part ii) clears the data

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about the active regions in the NIR region. For more details about the table information see appendix A.

4. Sunspot Measurements

Several types of sunspot measurements were implemented to determine the levels of the solar activity.

The daily sunspot number and area at each location of the sunspot groups indicate a general rise in the sunspot activity. Classification of the sunspot groups visible on the solar disk may be determined to know how many number of the frequent sunspot groups could cause strong solar activity.

4.1. Sunspot Locations

Location of the sunspot groups can be measured in terms of heliographic latitude and longitude for each group seen on the solar disk. The latitude and longitude of any feature on the photosphere of the Sun change with time. [8]

4.1.1 Latitudinal Distribution for the Sunspot Groups

Heliographic latitude for each sunspot group across the solar disk as a function of date is shown in Fig. 2. Distribution of the sunspot groups shows a variation between northern and southern hemisphere with more number of sunspot groups being in the southern hemisphere.

The daily motion of the sunspot groups over a heliographic latitude changes by an average +/- 0.5 degree and it tends to lie slightly closer to the equator.

4.1.2 East-West Distribution of the Sunspot Groups on the Solar Disk

East-West distribution of the sunspot over the Sun's central meridian is illustrated in Fig. 3. The start of the sunspot groups formation is usually at a higher longitude on the eastern limp of the central meridian. During the proper motion of the sunspot groups, the longitude will decrease by an average 13 deg. per day at the same time of the observation to reach its minimum values when the groups start to decay as the magnetic field strengths are weaken. [9]

4.2. Sunspot Number

The daily variation to both sunspot groups and sunspot numbers on January, 2007 is shown in Figs. (4; a, b).

The larger number of the sunspot groups during 01-31, January was cleared on 01-13, January. The group numbers gradually decrease on the period 14-24, January to rise again for the rest of the period. See Fig. 4, a.

The sunspot number can be used to predict levels of solar activity.

Generally, the solar activity during January, 2007 is low. Higher levels of solar activity occur on 01-13 January. Very low activity is during 14-24 January.

An increase in the solar activity happens during the remainder of the period. See Fig. 4, b.

Results of the CCD solar imaging system depict the levels of solar activity

on 02-04 January in the NIR region that are larger than in the visible region, this occurs also on 21-22

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January and 29 January, due to the increase in the number of visible sunspots in this region for the same appearing groups .

4.3. Sunspot Area

The measurement of the area of the sunspot groups is important from the point of view of studying the sunspots and their effect on the solar irradiance. [4]

For each daily observation, the total sunspot area is calculated and plotted as a function of date.

Fig. 5 shows the sunspot area in millionths of the Sun's visible hemisphere since January 01 until January 31 for each visible group on the surface of the Sun.

The sunspot groups areas in the NIR region are bigger than those in the visible region see Fig. 5, a and b.

The daily total area for the sunspot groups during 01-31 January is shown in Fig. 6. The figure illustrates that the larger area appears at the date of larger solar activity and lower area appears at date of lower solar activity.

4.4. Sunspot Classification

Classification of sunspot groups on the surface of the Sun according to McIntosh sunspot classification system is based on three criteria: the configuration of the sunspot groups, the type of the largest spot, and the distribution of the spots within the group. [10]

Table 2 gives the frequency of occurrence of the types of spot groups during 01-31 January, the frequency of occurrence for each of the previous groups of classification has been calculated from table 1 and displayed in Fig. 7.

It is clear from the previous figure that more frequent groups during this period are class H, and then class D, some of groups are classes c .

5. Conclusions

In this work special attention has been paid to observe and image sunspots in the 850 nm wavelength. Solar images in the visible are also recorded and compared with those obtained in near infrared. In general, the following concluding remarks have been reached.

1. Sunspot groups in the NIR seem darker and sharper than those observed in the VIS; bright sunspot has poor contrast in the VIS. This affects the sunspot measurements and leads to:
    a) Solar activity measurements R in NIR region are larger than in the VIS region.
    b) Individual sunspot groups areas in the NIR solar images are larger than those in the visible regions. Therefore, the daily total sunspot groups areas in NIR region are larger.
2. Allowed types of sunspot groups in McIntosh sunspot classification are the same in each of the NIR and the visible regions. Thus, the frequency of occurrence among the types of sunspot

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groups is the same.

Acknowledgments

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Appendix A: Solar Region Summary

The summary and the detailed description of the active regions visible on the solar disk are described as follows.

Description

Part I. Describes all active regions with sunspot groups.

Numb: An SESC regions number assigned to a sunspot group during its disk passage.

Location: Sunspot group location, in heliographic degrees (latitude and longitude) east or west from central meridian.

Lo: Carrington longitude of the group.

Area: Total corrected area of the group in millionths of the solar hemisphere.

Z: Modified Zurich classification of the group.

LL: Longitudinal extent of the group in heliographic degrees.

NN: Total number of visible sunspots in the group.

R: The sunspot number.

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Table(1) : Results of CCD solar imaging system in VIS and NIR regions on date 01-31 January, 2007.

	Sunspots Measurements								
	R	**NN**	**LL**	**Z**	**Area**	**Lo**	**Location**	**Nmbr.**	**Day**
Visible	11	01	05	Dso	0180	041	S03E51	0933	1
NIR	11	01	06	Dso	0190	041	S03E51	0933	
Visible	23	0201	0502	Dao Hrx	0210 0040	039 007	S03E38 N04E70	0933 0935	2
NIR	24	0301	0602	Dao Hrx	0230 0050	039 007	S03E38 N04E70	0933 0935	
Visible	23	02 01	01 03	Cho Hhx	0240 0200	037 009	S04E28 S06E56	0933 0935	**3**
NIR	24	03 01	01 03	Cho Hhx	0280 0200	037 009	S04E28 S06E56	0933 0935	
Visible	22	01 01	05 03	Dao Hhx	0180 0240	036 011	S05E16 S06E41	0933 0935	**4**
NIR	23	02 01	06 03	Dao Hhx	0200 0260	036 011	S05E16 S06E41	0933 0935	
Visible	22	01 01	06 01	Dao Hax	0150 0220	028 016	S05E04 S06E28	0933 0935	**5**
NIR	22	01 01	07 02	Dao Hax	0180 0240	028 016	S05E04 S06E28	0933 0935	
Visible	22	01 01	05 03	Cao Hax	0150 0180	033 012	S08W02 S05E16	0933 0935	**6**
NIR	22	0101	08 04	Cao Hax	0170 0200	033 012	S08W02 S05E16	0933 0935	
Visible	22	01 01	02 02	Hkx Cho	0150 0200	029 010	S05W16 S06W03	0933 0935	**7**
NIR	22	01 01	03 03	Hkx Cho	0160 0240	029 010	S05W16 S06W03	0933 0935	
Visible	22	01 01	02 02	Cki Hkx	0150 0230	032 009	S05W30 S07W09	0933	**8**

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								0935	
NIR	22	01 01	02 03	Cki Hkx	0170 0240	032 009	S05W30 S07W09	0933 0935	
Visible	22	01 01	04 02	Cki Hhx	0250 0220	033 011	S05W42 S07W23	0933 0935	**9**
NIR	22	01 01	05 03	Dhi Hhx	0270 0240	033 011	S05W42 S07W23	0933 0935	
Visible	22	01 01	04 03	Cao Hhx	0150 0190	042 012	S04E54 S07W37	0933 0935	10
NIR	22	01 01	04 03	Cao Hhx	0180 0210	042 012	S07W54 S07W37	0933 0935	
Visible	11	01	03	Hhx	0150	012	S06W51	0935	11
NIR	11	01	04	Hhx	0160	012	S06W51	0935	
Visible	11	01	02	Hsx	0170	011	S07W63	0935	**12**
NIR	11	01	02	Hsx	0180	011	S06W63	0935	
Visible								None	**13-20**
NIR								None	
Visible	12	02	04	Dac	0050	217	S01W29	0939	**21**
NIR	13	03	05	Dac	0070	217	S01W29	0939	
Visible	12	02	04	-	0070	214	N01W39	0939	**22**
NIR	13	03	05	Dso	0100	214	N01W39	0939	
Visible	12	02	05	Dai	0120	213	N02W51	0939	**23**

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NIR	12	02	05	Dai	0130	213	N02W51	0939	
Visible								None	**24-26**
NIR								None	
Visible	11	01	04	Hax	0150	039	S09E71	0940	**27**
NIR	11	01	04	Hax	0150	039	S09E71	0940	
Visible	11	01	05	Dao	0160	040	S08E57	0940	28
NIR	11	01	05	Dao	0140	040	S08E57	0940	
Visible	22	01 01	03 04	Dso Hsx	0170 0100	043 007	S07E40 S08E76	0940 0941	29
NIR	23	02 01	05 05	Dso Hsx	0200 0110	043 007	S07E40 S08E76	0940 0941	
Visible	23	02 01	05 02	Dao Hsx	0140 0090	038 009	S07E32 S05E61	0940 0941	**30**
NIR	24	03 01	05 03	Dao Hsx	0160 0100	038 009	S07E32 S05E61	0940 0941	
Visible	23	02 01	08 02	Dsi Hhx	0200 0100	040 011	S06E17 S04E46	0940 0941	**31**
NIR	23	02 01	08 03	Dsi Hhx	0200 0110	040 011	S06E17 S04E46	0940 0941	

Table (2) The frequency of occurrence of the 13 types of sunspot groups during January, 2007.

Frequency of occurrence:		**Sunspot types**
Visible	**NIR**	
	2	**Cao**
	1	**Cho**
2	**1**	**Cki**
1	**2**	**Dso**
1	**1**	**Dsi**

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1	6	Dao
1	1	Dac
6	1	Dhi
1	1	Hrx
1	3	Hsx
1	3	Hax
3	6	Hhx
3	2	Hkx
6		
2		

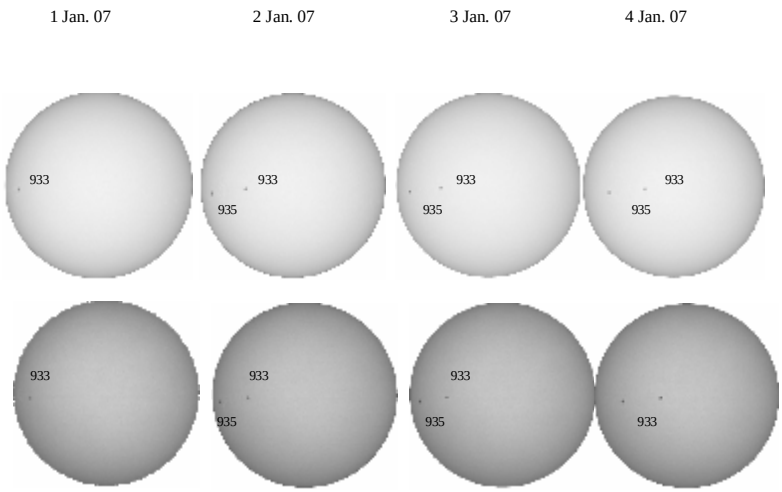

Figure (1) : solar image observed by CCD solar imaging system in a) VIS region b) NIR region

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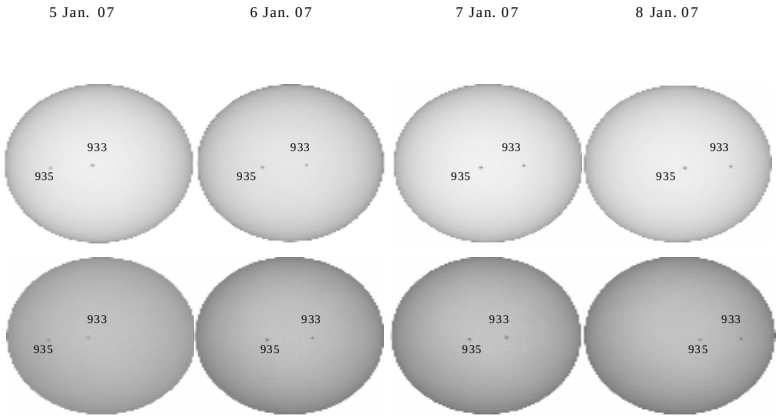

Figure (1) (Cont.)

Figure 1 (Cont.)

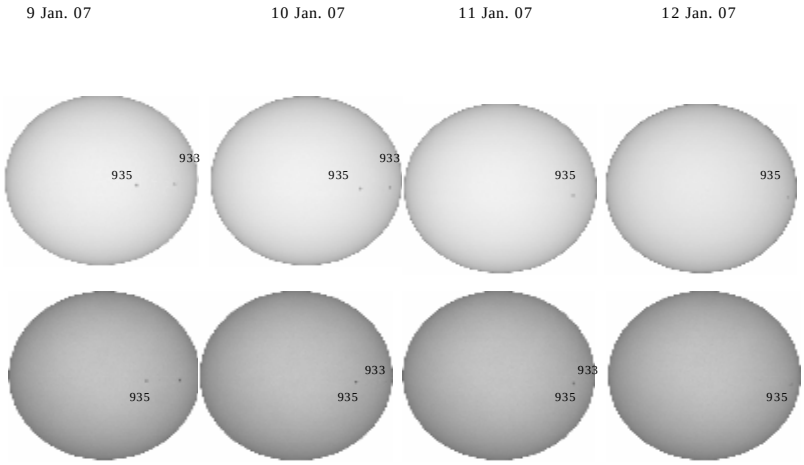

Figure (1) (Cont.)

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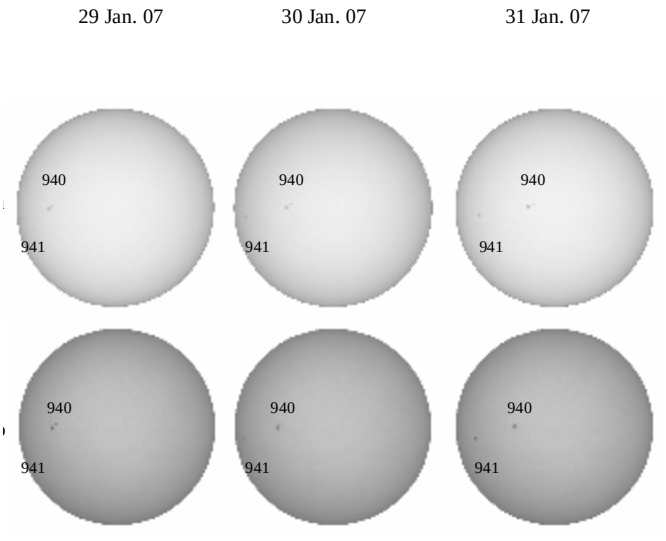

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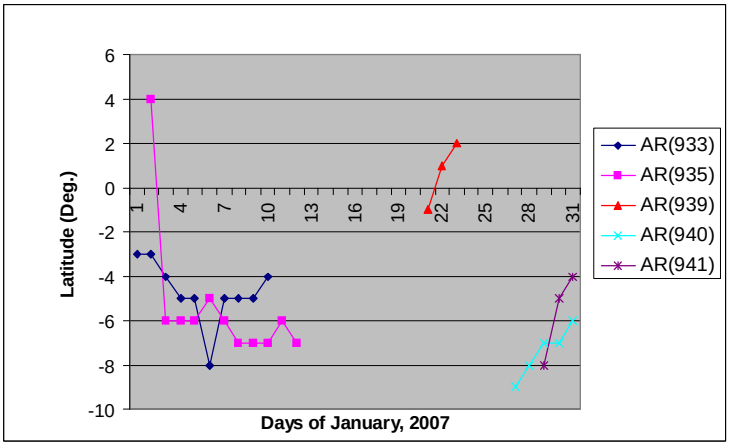

Figure (2) Latitudinal distribution for the sunspot groups on the solar disk.

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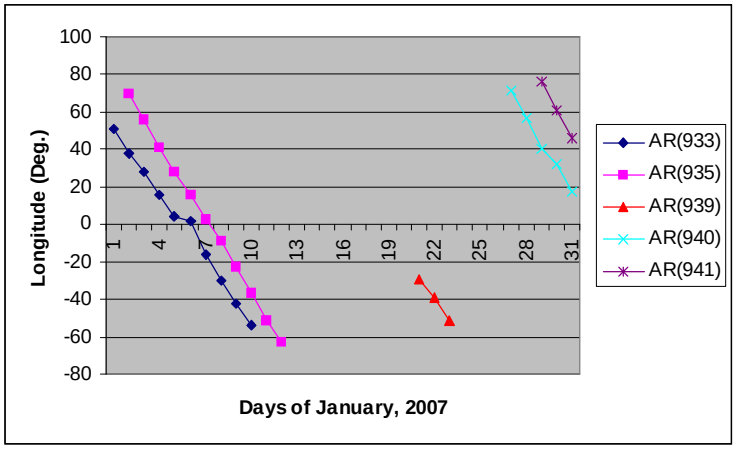
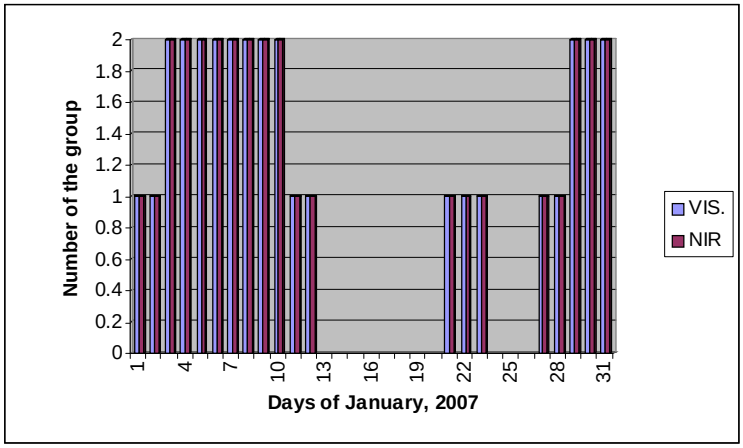


Figure (3) East - West distribution for the sunspot groups on the solar disk



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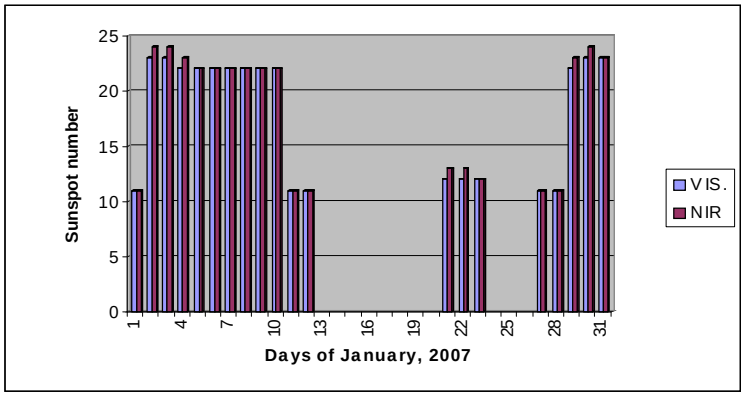

b)

Figure (4) a) Change of the number of the sunspot groups with date.
b) Change of the sunspot number with date.

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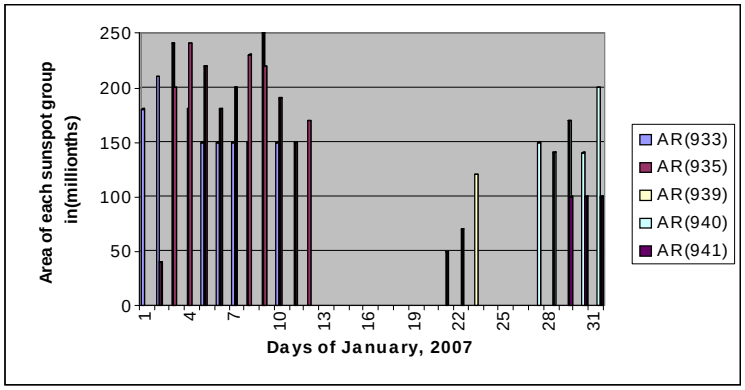
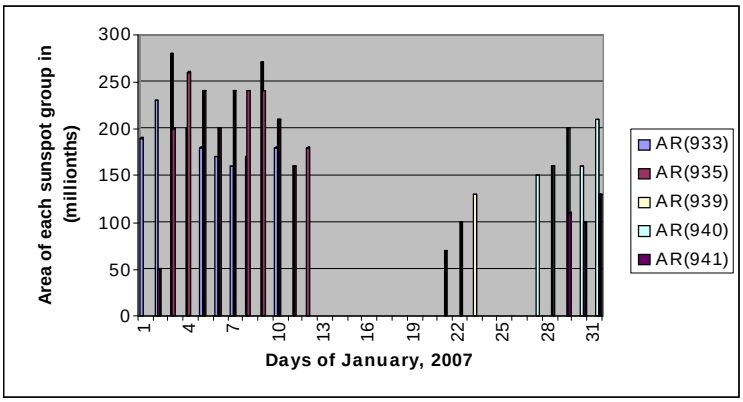


a)



b)

Figure (5) Sunspot area for each group at: a) visible region, b) NIR region.

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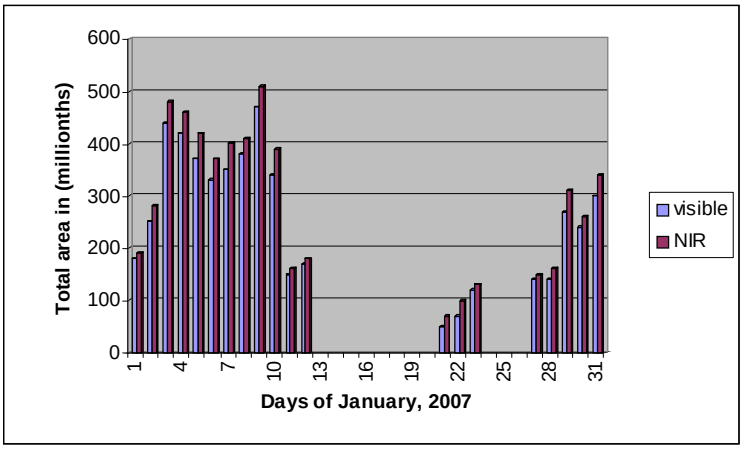

Figure (6).Total area of the groups as a function of date.

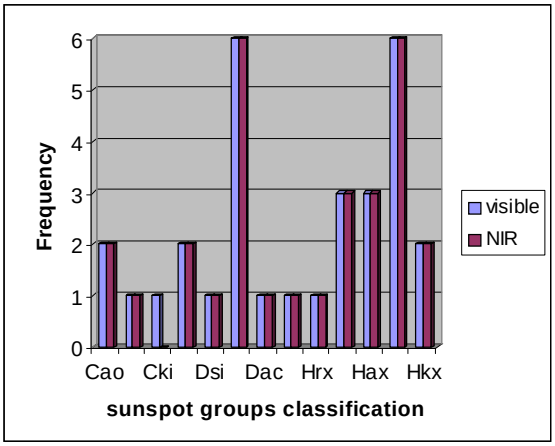

Figure (7) Frequency of occurrence among the types of sunspot groups

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