Study of Sunspot Effect on Radio Jove Telescope Observation

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Abstract

In this research, study the effect of sunspots on electromagnetic radio signals when it passed through F layer. The evaluation for this effect is carried out on radio Jove telescope frequency (20.1MHz) observations result. Radio emission for Jupiter storm burst observations over 11 years (1999-2009) from Hawaii, USA station (about 37611observations must be attended), are used in this research.

Two data limitations are applied on number of observation for Hawaii station, first due station location, second due to the reception of telescope antenna. The number of observations are reduced to 337 due to these limitation, but the actual number that be detected by station telescope is only 20.A model for ionospherical effect ,only due to sunspot number in observation day, is achieved in this paper. The behavior of this effect depending on actual observations (20 observations) is represented by polynomial equation of order degree three. The range of K sunspot value according the effect curve representation is determined by difference calculation between actual observation day sunspot number and the sunspot number must be to achieve the model curve this range is 25.

Keywords: Radio jove project, Radio jove telescope.

دراسة تأثير البقع الشمسية على ارصادات التلسكوب الراديوي جوفا

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الخلاصة:

في هذا العمل البحثي تم دراسة تأثير البقع الشمسية على الموجات الراديوية التي تمر خلال طبقة(F). تم تمييز هذا التأثير باستخدام Radio Jove Telescope وبتردد مقداره 20,1 ميغاهيرتز. تم استخدام بيانات محطة واحدة للرصد الراديوي هي محطة هاواي ولمدة 11 سنة للفترة من (1999–2009) والمتضمنة الدورة الشمسية 23، ومن خلال تطبيق الحسابات على بيانات هذا المحطة وجد بأنه من الممكن حدوث 37611 رصد راديو لكوكب المشتري وذلك نسبة إلى برنامج Radio Jove Software، ومن خلال تطبيق شرط الموقع وشرط استلام الهوائي الموجة على بيانات هذه المحطة وجد بأنه عند تطبيق هذه الشروط على 37611 رصد راديو تم الحصول على 337 رصد راديو، على الرغم من الرصدات التي حصلت فعلا وتم توثيقها هي 20 رصده نسبة إلى الأرشيف لبرنامج Radio Jove Software، تم دراسة تأثير عدد البقع الشمسية على الانبعاث الراديوي من كوكب المشتري وان تصرف أو سلوك هذا التأثير يعتمد على الرصدات التي حصلت فعلا والتي هي 20 رصده وذلك باستخدام معادلتي متعدد الحدود من الدرجة الثالثة. إن قيمة K الذي يمثل عدد البقع الشمسية يحدد نسبة إلى الفرق بين البيانات الحقيقة والبيانات الممكن حدوثها وتكون قيمة K ضمن المدى 25.

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1. Introduction

The ionosphere is that region of the Earth's atmosphere above ~50 km where solar radiation (in the form of ultraviolet light and X-rays) is sufficient to ionize atoms and molecules. The structure of the ionosphere is complex and varies greatly over time, but is generally divided into three distinct layers. The lower two layers, D and E, are unlikely to have a significant effect on this project because they only affect much lower frequencies. However, the top layer, F, will have a significant effect. The F layer, which exists from 160 km to more than 500 km above the Earth, is tenuous due to the low air density and is highly ionized. The main effect of the F layer is to reflect terrestrial signals back to Earth while preventing the transmission of extraterrestrial signals.

This works over a wide range of HF frequencies and is very effective at ~20 MHz. The exact ability to reflect, and the geometry of the reflection, is highly variable based on the angle and amount of solar incidence and electron density of F region. This effect is most likely responsible for the bulk of daytime interference in this project as manmade signals from around the world are reflected onto the radio telescope in a random and time varying fashion. During solar activity, the F layer can remain ionized for several hours after sunset. However, solar activity was at a minimum during this project, and thus the F layer quickly lost its ionization immediately after sunset. The F layer will also reflect extraterrestrial signals and prevent them from reaching the Earth's surface, [1].

This ability of the F layer is highly variable and is a function of the angle and electron density of solar incidence and the electron density of the layer. This is the reason why for a certain period of time every day when the layer was highly ionized, strong manmade signals from around the world were reflected onto our radio telescope preventing solar radiation to be detected[2].

As a result, Jovian emissions are not generally detectable during daylight hours, regardless of the noise background. Jovian studies are conducted mainly at night, and, since Jovian emissions are less intense than solar emissions and more likely to be covered by noise. Solar radiation ionizes portions of Earth's atmosphere making the sunlit half of the upper atmosphere mostly opaque to frequencies in the 20 MHz range. Such ionization can last from sunrise until several hours after sunset. As a result, observation of Jovian emissions must generally be conducted well after sunset and before sunrise. Solar observations must be conducted during daylight, but the intensity of solar emissions is such that they may be detectable even through the mostly opaque ionosphere[2].

2. Data Collection

Two websites are used to collect data for this research, and one software program forcollecting observation time these are explained as following:

2.1. Radio JOVE Data Archive

This NASA website is used to store the observations that are carried out by astronomical group using radio Jove telescope at frequency 20.1 MHz for Jupiter and some radio storm burst. The data archive including all observation information such as observer name, station location (latitude, longitude), observation date, time observation (start & end time), type of object storm (Sun, Jupiter). Observations from 1999 until today can be achieved from archive, data during eleven years (1999-2009) for Hawaii, USA station. The chosen of this station is depended on the higher number of observations are recorded in data archive[3].

2.2National Geophysical Data Center (NGDC)

In this data center, the estimation for daily solar activity is achieved by counting the number of individual spots and groups of spots on the face of the Sun. The collection of sunspot numbers provided the data center several kinds of tables, tables that give spot counts averaged over different time intervals. It is determined each day without reference to preceding days. Daily table from 1999 to 2009 are downloaded from the website of NGDC, these tables are used in data research analysis according to the radio Jove observation days[4].

3. Radio Jove Pro. Software

This program is designed to be able the astronomical observer using radio Jove telescope, it includes some features that are useful in predicting Sun and Jupiter storms, planning observations, and tracking of the motions of Jupiter and its moon Io. These features are used in research to calculate the number of storm Jupiter observations that must be achieved during eleven years (1999-2009), especially in Oahu, Hawaii, USA station[5].

4.Observation Limitation due to Station Location

According to Jupiter and its satellite Io movement, the Central Meridian Longitude (CML) is calculated using the radio Jove pro. Software. The CML occurrence with respect to Earth for eleven years (1999-2009) is achieved which are about (37611). This number gives an indication for the probability quantity that the observer can be detected a Jupiter radio storm burst using radio Jove telescope ,burst detection means that an observation at any station has been happen. The above number is minimized to (4018) due to the station location for the local time of Sun set and Jupiter rise. The intersection between these times makes the presence of Sun and Jupiter at same time above of the horizon of Earth. This presence makes the probability of detection Jupiter storm burst is low because the higher Sun radio emission density with respected to Jupiter radio emission.

5. Observation Limitation due to Radio Jove Telescope Antenna

The antenna of radio Jove telescope is a dipole antenna type as shown in the figure 1. If the Jupiter elevation height within antenna reception pattern range the telescope may be received and detected the burst storm. The Jupiter elevation for the eleven years at Oahu, Hawaii station is achieved from the Jove pro. Software using the software window as shown in figure 2. From this figure and according to the observations (ref), a range of 5 hours is determined (2.5 hr. before the peak maximum elevation and 2.5 hr. after this peak.) within this range the burst can be detected. Therefore because the two limitations (antenna pattern, Jupiter elevation) the probability of observation reduced to number (327), the reception pattern for this type is shown in figure 3 [6].

Figure 1- Completed Jove receiver and antennasetup[6].

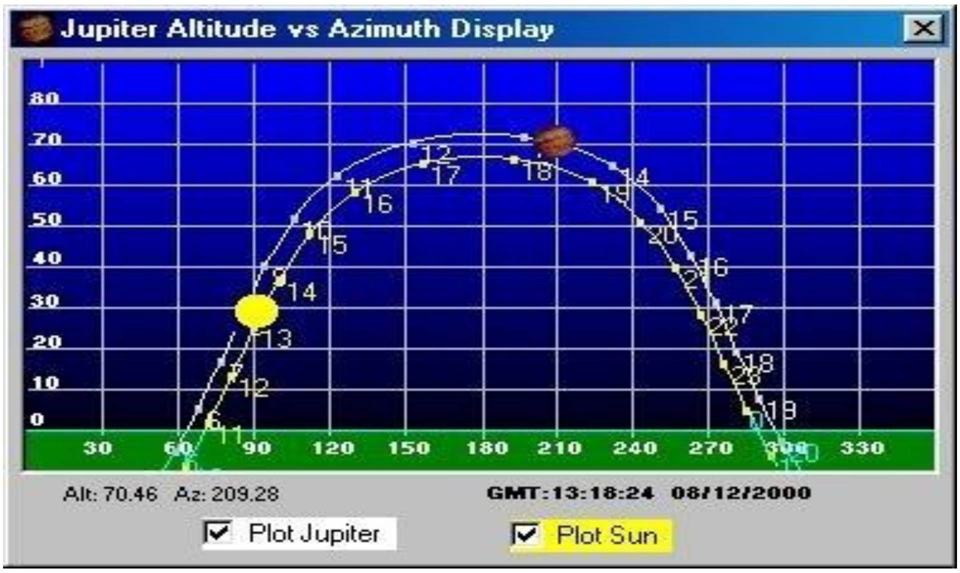


Figure 2- Altitude and azimuth plot of Radio Jupiter Pro [5].

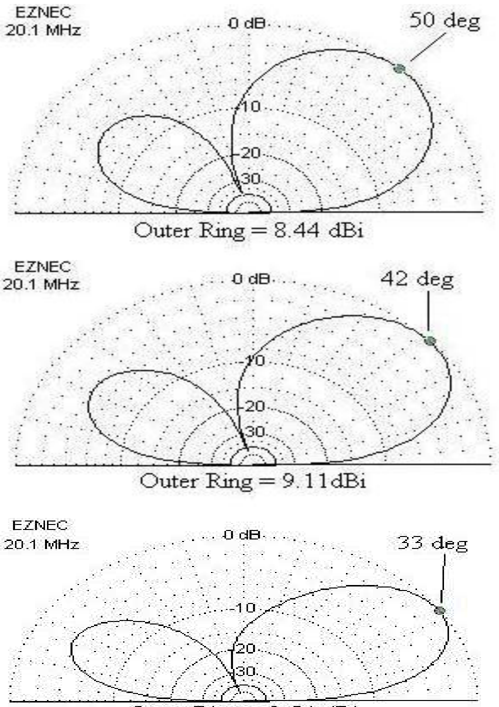


Figure 3- Antenna heights for 10, 15 and 20 feet[6].

6. Research Data Analysis Procedure [7]

The actual observations, in Oahu, Hawaii station are taken from radio Jove data archive, are tabulated according to data of observation, type of satellite Io storm, start time, end time of observation (see table 1). From this table the number of actual observations is only 20, this lead to study in this research the effect of this reduction in the number.

Table 1- The actual observations for Oahu, Hawaii station, date, time of observations and type of bursts [3].

Date of observations	Time of observation	Type of burst
29/9/2000	13:35	Io-C
8/9/2002	15:35	Io-B
14/9/2002	15:27	Io-C
15/9/2002	16:10	Io-B
17/12/2002	10:35	Io-A
18/12/2002	1253	Io-B
25/12/2002	13:52	Io-B
1/1/2003	15:07	Io-B
7/1/2003	12:11	Io-A
27/2/2003	05:54	Io-B
6/3/2003	06:45	Io-B
13/12/2003	13:34	Io-A
14/12/2003	14:12	Io-B
15/4/2008	13:59	Io-B
21/4/2008	14:50	Io-C
28/4/2008	15:46	Io-C
29/4/2008	15:16	Io-B
23/5/2008	10:51	Io-C
18/4/2009	16:51	Io-B

The ionosphere is the mainly reason of absorption for Jupiter radio signal (20.1 MHz), research study is focused on the sunspot number (SSN) in observation day for determination ionosphere effect.

Therefore a table for sunspot number relate to the days (Julian day) of 337observations are taken from NGDC data centre including the days of actual observations (see table (2)).

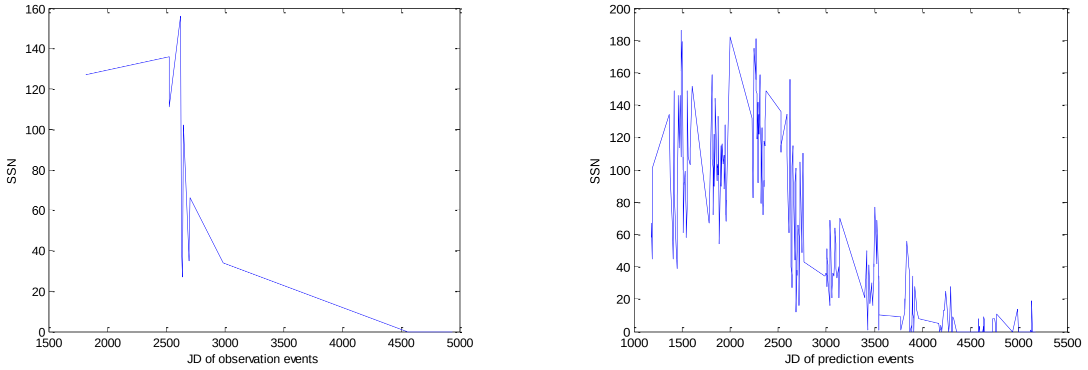
Table 2- Sunspot number relate to the Julian days of 337 observations.

Date of observations	SSN	JD of observations+ (2450000-0.5)	Date of observations	SSN	JD of observations+ (2450000-0.5)	Date of observations	SSN	JD of observations+ (2450000-0.5)
3/1/1999	58	1182	8/11/2000	122	1857	14/9/2002	111	2532
4/1/1999	65	1183	14/11/2000	93	1863	15/9/2002	115	2533
10/1/1999	46	1189	16/11/2000	94	1865	9/11/2002	134	2588
17/1/1999	93	1196	17/11/2000	103	1866	15/11/2002	109	2594
11/7/1999	115	1371	23/11/2000	101	1872	22/11/2002	81	2601
18/7/1999	90	1378	24/11/2000	97	1873	29/11/2002	61	2608
13/8/1999	67	1404	30/11/2000	133	1879	17/12/2002	156	2626
19/8/1999	42	1410	7/12/2000	68	1886	18/12/2002	152	2627
20/8/1999	48	1411	10/12/2000	54	1889	24/12/2002	61	2633
26/8/1999	136	1417	26/12/2000	115	1905	25/12/2002	40	2634
27/8/1999	128	1418	1/1/2001	90	1911	31/12/2002	35	2640
2/9/1999	82	1424	8/1/2001	116	1918	1/1/2003	27	2641
4/9/1999	69	1426	15/1/2001	104	1925	2/1/2003	32	2642
9/9/1999	73	1431	27/1/2001	109	1937	7/1/2003	102	2647
21/9/1999	44	1443	2/2/2001	88	1943	9/1/2003	115	2649
27/9/1999	35	1449	3/2/2001	102	1944	14/1/2003	99	2754
28/9/1999	46	1450	9/2/2001	128	1950	1/2/2003	44	2672
4/10/1999	77	1456	10/2/2001	103	1951	2/2/2003	45	2673
5/10/1999	124	1457	16/2/2001	68	1957	8/2/2003	92	2679
6/10/1999	136	1458	18/2/2001	81	1959	9/2/2003	101	2680
11/10/1999	126	1463	23/2/2001	72	1964	10/2/2003	84	2681
13/10/1999	157	1465	3/4/2001	182	2003	15/2/2003	22	2686
18/10/1999	114	1470	13/11/2001	132	2227	17/2/2003	12	2688
20/10/1999	113	1472	20/11/2001	83	2234	22/2/2003	38	2693
27/10/1999	140	1479	26/11/2001	86	2240	26/2/2003	35	2697
5/11/1999	102	1488	3/12/2001	175	2247	27/2/2003	43	2698
6/11/1999	103	1489	5/12/2001	174	2249	6/3/2003	66	2705
12/11/1999	188	1495	22/12/2001	156	2266	12/3/2003	59	2711
13/11/1999	164	1496	28/12/2001	181	2272	13/3/2003	56	2712
19/11/1999	164	1502	29/12/2001	149	2273	19/3/2003	41	2718
21/11/1999	142	1504	4/1/2002	147	2279	20/3/2003	32	2719
26/11/1999	95	1509	5/1/2002	119	2280	21/3/2003	16	2720
28/11/1999	105	1511	11/1/2002	142	2286	26/3/2003	71	2725
5/12/1999	51	1518	18/1/2002	92	2293	28/3/2003	105	2727
14/12/1999	104	1527	20/1/2002	118	2295	4/4/2003	79	2734
15/12/1999	92	1528	22/1/2002	134	2297	20/4/2003	49	2750
22/12/1999	94	1535	23/1/2002	128	2298	21/4/2003	62	2751
23/12/1999	89	1536	28/1/2002	126	2303	30/4/2003	110	2760
27/12/1999	69	1540	29/1/2002	192	2304	13/5/2003	43	2773
28/12/1999	62	1541	5/2/2002	159	2311	13/12/2003	34	2987
30/12/1999	48	1543	6/2/2002	128	2312	14/12/2003	34	2988
31/12/1999	57	1544	12/2/2002	115	2318	27/12/2003	36	3001
6/1/2000	76	1550	13/2/2002	114	2319	28/12/2003	35	3002
13/1/2000	149	1557	14/2/2002	98	2320	29/12/2003	28	3003
20/1/2000	108	1564	19/2/2002	79	2325	3/1/2004	51	3008
8/2/2000	103	1583	21/2/2002	81	2327	5/1/2004	46	3010
14/2/2000	113	1589	26/2/2002	126	2332	10/1/2004	41	3015
28/2/2000	152	1603	28/2/2002	109	2334	12/1/2004	32	3017
23/8/2000	67	1780	3/3/2002	96	2337	29/1/2004	16	3034
23/9/2000	159	1811	10/3/2002	72	2344	4/2/2004	68	3040
29/9/2000	127	1817	16/3/2002	93	2350	5/2/2004	69	3041

30/9/2000	107	1818	17/3/2002	90	2351	11/2/2004	49	3047
6/10/2000	101	1824	23/3/2002	112	2357	13/2/2004	47	3049
8/10/2000	72	1826	24/3/2002	118	2358	18/2/2004	21	3054
13/10/2000	122	1831	30/3/2002	115	2364	20/2/2004	25	3056
15/10/2000	90	1833	1/4/2002	130	2366	8/3/2004	57	3073
29/10/2000	114	1847	8/4/2002	149	2373	15/3/2004	34	3080
1/11/2000	144	1850	8/9/2002	136	2526	21/3/2004	51	3086
23/3/2004	64	3088	22/6/2006	0	3909	15/7/2008	0	4663
24/3/2004	63	3089	24/6/2006	0	3911	16/7/2008	0	4664
30/3/2004	54	3095	29/6/2006	28	3916	22/7/2008	0	4670
6/4/2004	39	3102	24/7/2006	13	3941	24/7/2008	0	4672
15/4/2004	33	3111	3/3/2007	8	4163	31/7/2008	0	4679
16/4/2004	33	3112	12/3/2007	5	4172	1/8/2008	0	4680
1/5/2004	40	3127	18/3/2007	0	4178	7/8/2008	0	4686
2/5/2004	33	3128	19/3/2007	1	4179	14/8/2008	0	4693
8/5/2004	21	3134	25/3/2007	1	4185	17/8/2008	0	4696
15/5/2004	70	3141	1/4/2007	4	4192	1/9/2008	0	4711
30/1/2005	21	3401	3/4/2007	1	4194	2/9/2008	0	4712
31/1/2005	24	3402	8/4/2007	0	4199	8/9/2008	0	4718
6/2/2005	33	3408	27/4/2007	13	4218	9/9/2008	0	4719
8/2/2005	34	3410	4/5/2007	13	4225	15/9/2008	0	4725
15/2/2005	50	3417	10/5/2007	15	4231	22/9/2008	8	4732
16/2/2005	43	3418	12/5/2007	16	4233	11/10/2008	9	4751
22/2/2005	20	3424	17/5/2007	25	4238	17/10/2008	8	4757
1/3/2005	1	3431	11/6/2007	11	4263	18/10/2008	0	4758
4/3/2005	9	3434	12/6/2007	9	4264	24/10/2008	0	4764
11/3/2005	41	3441	13/6/2007	8	4265	26/10/2008	0	4766
20/3/2005	25	3450	18/6/2007	0	4270	31/10/2008	9	4771
26/3/2005	24	3456	20/6/2007	0	4272	2/11/2008	11	4773
27/3/2005	17	3457	25/6/2007	7	4277	18/4/2009	0	4940
2/4/2005	24	3463	13/7/2007	28	4295	3/6/2009	14	2986
9/4/2005	30	3470	14/7/2007	27	4296	18/6/2009	0	5001
12/4/2005	24	3473	20/7/2007	0	4302	21/7/2009	0	5034
21/4/2005	16	3482	21/7/2007	0	4303	27/7/2009	0	5040
27/4/2005	20	3488	22/7/2007	0	4304	28/7/2009	0	5041
28/4/2005	32	3489	27/7/2007	0	4309	3/8/2009	0	5047
4/5/2005	42	3495	29/7/2007	9	4311	13/8/2009	0	5057
5/5/2005	40	3496	5/8/2007	8	4318	22/8/2009	0	5066
11/5/2005	77	3502	7/9/2007	0	4351	28/8/2009	0	5072
30/5/2005	42	3521	15/4/2008	0	4562	29/8/2009	0	5073
5/6/2005	63	3527	21/4/2008	0	4578	4/9/2009	0	5079
6/6/2005	69	3528	22/4/2008	8	4579	5/9/2009	0	5080
12/6/2005	50	3534	28/4/2008	0	4585	11/9/2009	0	5086
19/6/2005	30	3541	29/4/2008	0	4586	18/9/2009	0	5093
21/6/2005	34	3543	30/4/2008	0	4587	20/9/2009	0	5095
26/6/2005	1	3548	5/5/2008	8	4592	7/10/2009	0	5112
28/6/2005	10	3550	7/5/2008	0	4594	13/10/2009	0	5118
9/2/2006	9	3776	12/5/2008	0	4599	14/10/2009	0	5119
11/2/2006	1	3778	14/5/2008	0	4601	20/10/2009	1	5125
16/3/2006	12	3811	23/5/2008	0	4610	22/10/2009	0	5127
22/3/2006	20	3817	30/5/2008	0	4617	27/10/2009	19	5132
23/3/2006	14	3818	31/5/2008	0	4618	3/11/2009	0	5139
5/4/2006	56	3831	6/6/2008	0	4624	22/11/2009	0	5158
30/4/2006	42	3856	7/6/2008	0	4625	5/12/2009	0	5171
1/5/2006	40	3857	8/6/2008	0	4626			
7/5/2006	36	3863	13/6/2008	8	4631			
14/5/2006	1	3870	14/6/2008	0	4632			
16/5/2006	0	3872	15/6/2008	7	4633			

1/6/2006	4	3888	20/6/2008	8	4638
2/6/2006	0	3889	22/6/2008	8	4640
8/6/2006	34	3895	23/6/2008	0	4641
9/6/2006	31	3896	29/6/2008	0	4647
15/6/2006	11	3902	6/7/2008	0	4654
17/6/2006	8	3904	9/7/2008	0	4657

The first research procedure, the data of actual observation (20) in Table 1 is plotted with sunspot number (SSN), and the polyfit function in MATLAB language is applied to find the equation of behavior. The second procedure, the data of 337 in Table 2, are plotted by using MATLAB language, see figure 4.



(A) **(B)**

Figure 4- case (A) for actual observations (20) and SSN, while case (B) for the prediction observations (337) and SSN.

When studying the information in figure(4B), it is found that the variation of sunspot number having high rate variation. So, it is suggested in this work to divided the range into three regions. The first region contains 7 points and the second region contains 3 points while the last region contains 4 points. The three regions can be divided using equation (1).

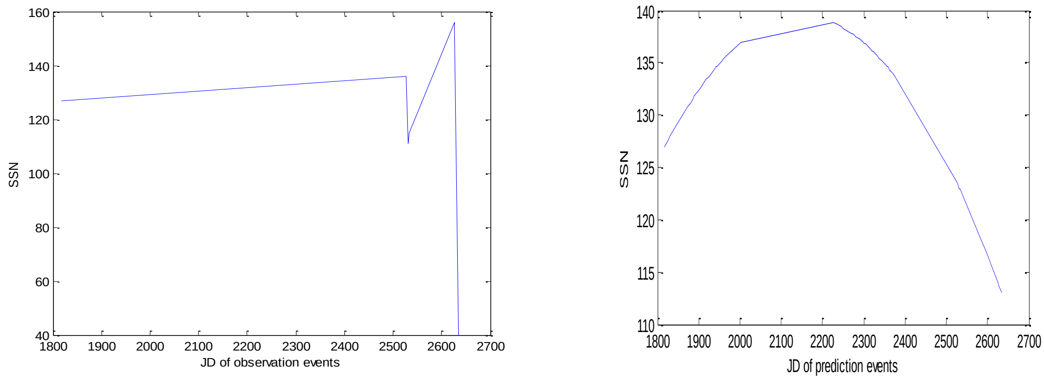
d= a2/a1………………………………….. (1)

Where: d represents the rate of variation, (d= no. of events/ a1).

a1 represents the observation day in Julian day.

a2 represents the daily sunspot number for the same JD.

For each range there are three figures. The first figure is for the observation data which contains 7 points as shown in figure 5A, from this figure a polyfit is found for these data. The second figure using the prediction data containing 76 points which covered the above range. From figure 5B it is found that the polyfit for these points is similar to the polyfit of figure 5A. The third figure 6 the actual prediction data is plotted.



(A) **(B)**

Figure 5- case (A) for sunspot number (SSN) variation as a function to Julian day (JD) of observation events (contain 7 points) for region one, case(B) for sunspot number (SSN) variation as a function to Julian day of prediction events (contain 76 points), for region one.

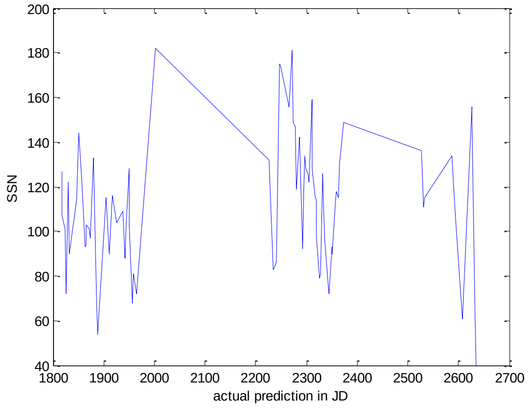


Figure 6- Sunspot number (SSN) variation as a function to actual prediction in Julian day (JD), for region one.

In the second region 3 points from 20 observation events are used. The first figure is for the observation data which has 3 points as shown in figure 7A; from this figure it was found the polyfit. The second figure used the prediction data containing 15 points which covered the above range. From figure 7B it is found that the polyfit for these points is similar to the polyfit of figure 7A. In third figure 8 the actual prediction data are plotted.

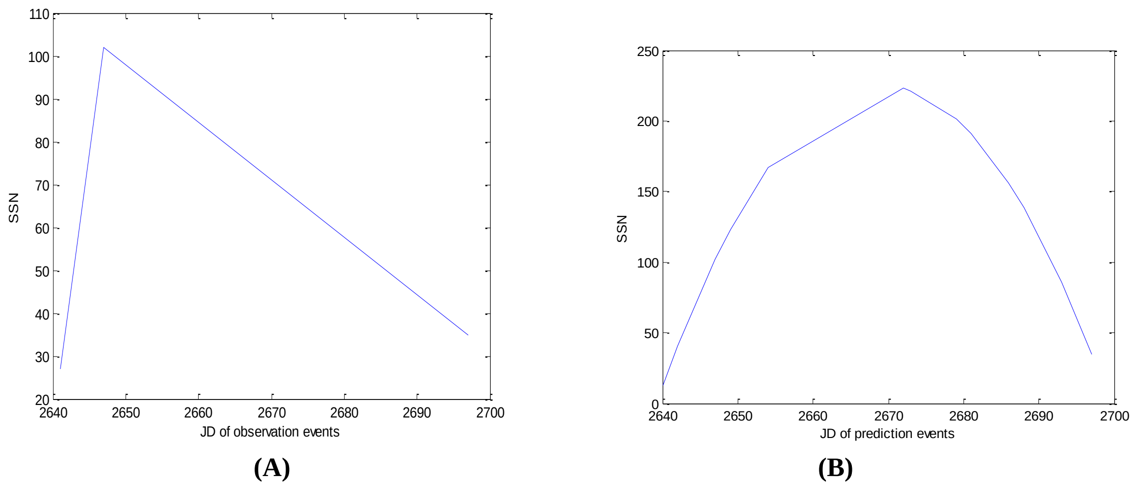


Figure 7- case(A) for sunspot number (SSN) variation as a function to Julian day (JD) in observation events(contain 3 points), for region two, case(B) for sunspot number (SSN) variation as a function to Julian day (JD) in prediction events (contain 15 points), for region two.

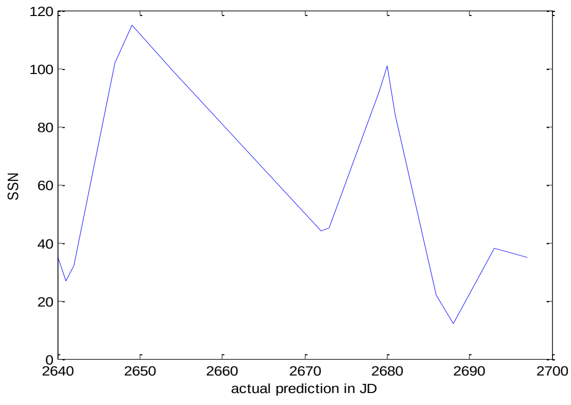
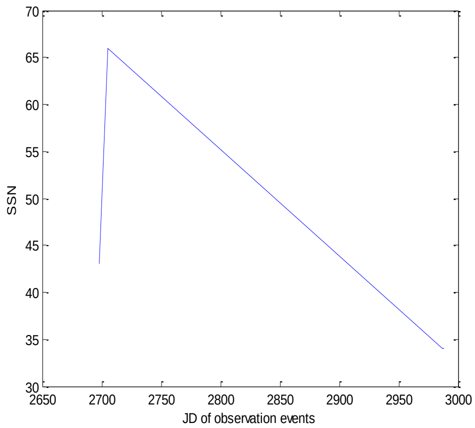
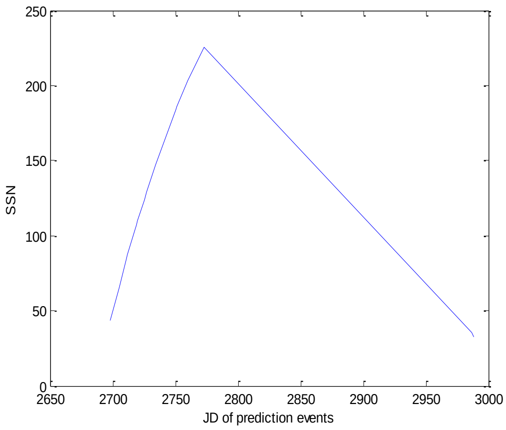


Figure 8- Sunspot number (SSN) variation as a function to actual prediction in Julian day (JD), for region two.

In the third region 4 points from 20 observations events are used. The first figure is for the observation data which has 4 points as shown in figure 9A; from this figure it was found the polyfit. The second figure used the prediction data containing 15 points which covered the above range. From figure 9B it is found that the polyfit for these points is similar to the polyfit of figure 9A. In third figure10 the actual prediction data are plotted.





(A) **(B)**

Figure 9- case(A) for sunspot number (SSN) variation as a function to Julian day (JD) of observation events (contain 4 points), for region three, case(B) for sunspot number (SSN) variation as a function to Julian day (JD) in prediction events (contain 16 points), for region three.

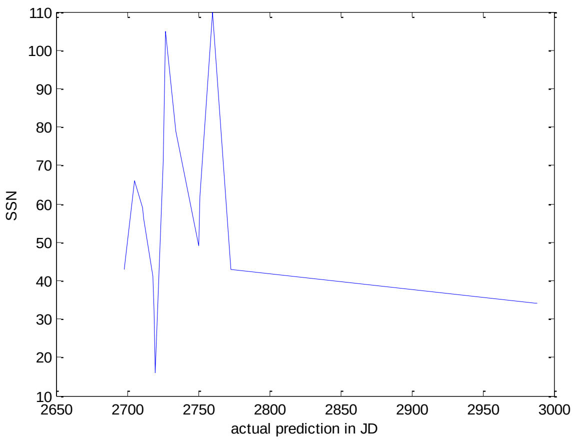


Figure 10- Sunspot number (SSN) variation as a function to the actual prediction in Julian day (JD), for region three.

7. Discussion and Conclusion

1. From the study of number of observation for Oahu, Hawaii station for interval 1999-2009 years, for analysis the curve (4B) to find the relationship between the daily sunspot number with number of actual observation, we are divided the curve into three curves as in the figures (5 and 7), to make the analysis more conventional.

2. The range division for curve (4B) is carried out depending on the study of the data behavior of curve, when we taken three points and calculated the sign of slope and then taken another three points and so on to be divided the curve (6), which have a high rate variation into the curves with low rate variation.

3. The value of sunspot number for observation in Julian day, which mustbe add to obey the curve figure 5B, this for Sunspot number effect on the observation happened.

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