Correlation between solar and seismic activity: prognosis of earthquakes and volcanic eruptions based on daily solar indexes

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Large earthquakes and volcanic eruptions are compared with the epochs of minima of 11-year cycles of solar activity. We use the data from 405 earthquakes with magnitude 7 and more and 71 volcanic eruption during 260 years. Close correlation between years of these terrestrial events and years of minima of solar activity is shown. We also use also ***daily*** solar indexes SSp and compare them with terrestrial events, constituting the main novelty of this work. Here we use the data of earthquakes between December 856 and January 2016, as well as data of volcanic eruptions in the same period. We subsequently compare ***daily*** indexes SSp during 2016 and 4 months of 2017 with earthquakes and volcanic eruptions. An important results is demonstrated: as soon as solar activity curve begins to go down, on the same day or some days after the earthquakes and volcanic eruptions occur. Evidently, this circumstance could be used for prognosis of these terrestrial events for several days in advance. In all cases considered our prognosis is confirmed. This is the main result of this article.

Key words: earthquakes, volcanic eruptions, solar activity, prognosis.

1 Introduction

Perhaps the first trustworthy evidence of seismic activity is the eruption of volcano Vezuvii (August 24-25, year 79) which led to destruction of Pompei and 2000 fatalities. Then, on December 22 year 856 there was an earthquake in Northerh Iran with 200,000 victims. On September 30, 1139, the earthquake near Gyandza: 250,000 fatalities. On January 23, 1556, there was the "Great Chinese earthquake" with 830,000 victims. Then we know about the earthquake in Calcutta (India): 300,000 fatalities. On August 26-27, 1853, there was the eruption of volcano Krakatau between Sumatra and Java (Indonesia). In our time, December 26, 2004, there was underwater earthquake with magnitude 9.1-9.3 in the Indian ocean and tsunami with 300,000 victims; economic loss was about 10 milliards dollars. On February 27, 2010 – the earthquake and tsunami in Chile, magnitude 8,8 and economic loss 15-30 billions dollars. On the same year (2010) – tsunami in Haiti with 316,000 fatalities. Then, on March 11, 2011, near island Khonsyu (Japan), there was an underwater earthquake with a magnitude 9.0-9.1. After 10-30 minutes, the giant wave, 40 meters high, reached the beach, resulting in 20,352 victims and economic loss of 225 billion dollars. In the former Soviet Union we remember Ashkhabad earthquake (October 1948), Tashkent (April 26, 1966) and Armenia earthquakes (December 7,1988). Here, is Armenia, the city Spitak and it's environments had been destroyed and number of victims was 25,000. This was followed by an earthquake in Sakhalin (May 28, 1995) with a magnitude 7.2 and buildings destruction; on December 1, 2001 with a magnitude of 7.0 and on August 2, 2007 with magnitude 6.8; an earthquake in the Kuril islands on April 2013 with a magnitude 6.7; an earthquake in Kamchatka on January 30, 2016 and so on.

The list could be continued. It's quite natural that scientists for many years have been trying to predict such events. The special Imperial committee for prediction of earthquakes was formed in 1892 in Japan; the corresponding investigations in USA began on 1960 after the California earthquakes; a special commission for this aim exists in the Knesset of Israel, etc. Some indicators were used as predictors of earthquakes, such as the velocity of seismic waves, level of water in thewells, strange behavior of animals, etc.

Unfortunately the results of all these attempts are negligible. From our point of view, the main reason is that the loocs of these researchers are directed down, to the Earth, and not up to the Sun. Meanwhile in 1857 Rudolf Wolf suggested the idea that earthquakes are connected with solar activity. After this, some attempts have been made to use this idea in practice, but first serious investigation belongs to founder of heliogeophysics M.S. Eigenson and his collaborators [1-3]

We can not list all investigations in this area and will mention only fundamental books by B. M. Rubashev [4], V. N. Obridko [5], N. N. Stepanyan [6], Yu. I. Vitinsky [7,8], S.I. Akasofu and S. Chapman [9], I.N. Artroshchenko et al. [10], G.S. Ivanov-Kholodny [11] , I. L. Linsky [12], N. L. Grigorov[13], Ch.A. Lundquist and U.U. Vogen [14], A.D. Sytinsky [15], V.I. Kozlov, P.F. Krymsky [16], as well as papers [17-31]. From the "other side" – geology – we can name the books of V.A. Aprodov [32], D.Gir and Kh. Shakh [33], V.B Lyatsky [35], E. Roberts [35], P. Russo [36], J. Khodson [37], V.S. Voropilov [38].

Owing to the courtesy of T.L. Gulyaeva from IZMIRAN (Troitsk, Moscow region) I had the possibility to become acquainted with her very interesting investigation [39] which anticipates some of our results. As far as I know, she was the first who discovered an anticorrelation between solar and seismic activity in cycles 19-23: low values of W correspond to high number of earthquakes.

Recently D. Grishchenko from Mogilev (Belorussia) published the data about earthquakes in California and pointed out that intervals between them were, in average, 22 years [40]. This number was thought-provoking, and was the new impetus for continuation of our own investigations.

1. Data and analysis

We use the most complete catalogue of earthquakes with magnitude 7 and more (http.://earthquake.usds.gov) and all available data (http.://en.wikipedia.org/wiki/lists_of_earthquakes). As for volcanic eruptions, we use: (www.infoniac.ru/news; https.:/ru.wikipedia.org/iria.ru/jprovka/20130826/958101173.html.earthchronicles. ru/news/2013-12-16-56152; photographo. Livejonrnal.com/ 86681.html.) First of all our compilation includes information about 405 earthquakes and 71 volcanic eruptions. Full tables are presented elsewhere. Here we present tables 1 and 2 with data of earthquakes and volcanic eruptions between August, 79 A.D. and 2016 years. The comparison of years of these events with years of solar activity minima is shown in Figs. 1, 2.

We note that plotting the random data in Fig. 1 and 2 is expected to give a certain correlation - independently of any physical connection existing. To account for this circumstance we performed simulation where two time series, the years of solar minima and the random numbers distributed by Poisson law, are compared. This approach is chosen because the distribution of earthquakes on time during cycles 19-23 resembles approximately the Poisson law. We consider 10 realizations and calculate the correlation coefficient for each realization. All these coefficients are in the range 0.11 - 0.42. It's considerably smaller than the actual coefficients implying that the correlations between solar and terrestrial events are highly significant.

In Fig. 3 we present the distribution of earthquakes on the "average" 11-year solar cycle. We use here the well-known method of superposition of epochs. It's seen that earthquakes occur in all parts of 11-year cycle, but the most probable is their occurrence on a minimum or the next year. Indeed, the hypothesis about uniform distribution is rejected by χ^2 – criterion.

It’s interesting to compare the number and power of earthquakes and the number of volcanic eruptions with the values of the Wolf number W. This comparison is shown in Fig. 4. We see that the decrease of solar activity leads to the increase of the number and power of earthquakes as well as to the increase the number of the volcanic eruptions.

In Fig. 5 we compare the number of these terrestrial events with the minimal values of W in all cycles and observe the exact coincidence.

Note that from the point of view of mathematics, we deal with some time series. Correspondingly, the usual methods of time series analysis could be used (see, e.g., [41-43]). An interested reader is referred to the book by V. Yu. Terebizh [44].

We note also the recent approach of theanalysis of time series by the author [45]. The main idea is that every curve could be approximated by thestep function, and the heights of these steps are used as parameters in matrix constructed by principle object – property. After this, the usual methods of multidimensional statistical analyses could be used such as the cluster analysis, factor analysis, principal components analysis and pattern recognition (see, e.g., [46-59]).

The value of any prognosis increases if we predict not only the time but also the location of corresponding events. This is shown in table 3 for some seismic-active regions. Note that for the California we include also some earthquakes which were not so strong. Some of these data are illustrated in Fig. 6-9.

We next consider the monthly averaged Wolf numbers and compare them with numbers of earthquakes in the last two years, 2015 and 2016. Perhaps the most impressive is the sharp increase of earthquakes number which corresponds to the decrease of solar activity. On 2016, the minimum of solar activity was in July. Again, this corresponds to the increase of earthquakes number.

Then we compare daily W or SSp for earthquakes and volcanic eruptions at last 260 years and especially for 12 months of 2016 and January-April 2017. The results are shown in Fig (14- 57), and summarized in theTables.

Hence, a sharp decrease of daily W corresponds to the likelihood of earthquakes. The earthquakes are likely occur in a few days time, with the time lag of up to 10 days as follows from an our analysis. For example, the decrease of W was on 28 February, 2016; the corresponding earthquake in Sumatra with magnitude 8.2 was March 2, i.e. 2 days after (Fig. 11). Going back, we see that earthquake in Armenia (December 7, 1988) also could be predicted (Fig.13).

3. Discussion

First of all we remind that the geophysical responses are not necessarily connected with absolute extremum of solar activity but rather with the epoch. Ignoring this could lead to thequite opposite result [60].

Many years ago my teacher V.A. Ambatsumyan [61] said that there are 3 stages of scientific perception: scheme, model and theory. Here I discuss the scheme only.

We recall that the 22-year solar cycle is not the simple sum of two 11-year cycles but has very important feature. Namely, in one 11-year cycle the solar spots have one polarity of magnetic field, but in the next cycle this polarity changes to the opposite. This change occurs in the minimum of 11-year cycle. Therefore, the change of electromagnetic radiation of Sun occurs in a minimum. Moreover, there is an addition radiation in the polar regions of the Sun in millimeter range in a minimum [62]. Both radiations could play the role of "trigger" which provokes the terrestrial processes. Indeed, the lithosphere plates in viscous magma of the Earth's upper mantle have their own magnetic field. The field interaction could give the impetus for earthquakes and volcanic eruptions.

From the continuation of Table 1 we see that the probability of earthquakes for *zero* day (day of curve fall) is 12%, for the first day – 27%, and for the next days correspondingly 19%, 15%, 11%, 6%, 4%, 1%, 2%, 2%, 0,5%.

4. Plans and perspectives

In future it will be interesting to make the following investigations:

1. To find evidences of earthquakes and volcanic eruptions from all possible sources of the ancient times.

2. To make cluster analysis, factor analysis, principal components analysis and pattern recognition of corresponding matrix.

3. To use some other indicators of solar activity, especially the indexes proposed in 1939-1940 by M. S. Eigenson [3]. Although these indexes are known at comparatively short times, some conclusions could be achieved even with limited data (see, e.g. [63]).

4. To include the earthquakes which are not so strong, for example with magnitude about 5 or even smaller.

All this would be the theme of our next article (of course, if the directorate of the Lviv astronomical observatory would not put a spoke in my wheel).

5. Conclusions

We show a very close correlation between solar and seismic phenomena. Solar activity can be predicted for many years ahead, and even for months and days. It means that we can make prognosis of earthquakes and volcanic eruptions for several days in advance. In all cases considered our prognosis is confirmed. This is the main result of this article.

Table 1. Earthquakes

	Earthquake			**Solar min**
Numbers	**Date**	**Zone**	**Magnitude**	**(year, month)**
1	856, 12, 22	North Iran		856
2	1139, 9, 30	Guandzha		1139
3	1556, 1, 23	China		1554
4	1737	India		1734
5	1755, 11	Iran		1755, 11
6	1756, 6	Portugal	8,7	1755, 6
7	1783, 2	Italy		1784
8	1812, 3	Venezuela	7,3	1810, 12
9	1821, 7	Peru	8,2	1823, 5
10	1835, 2	Chile	8,2	1833, 11
11	1843, 2	Leeward Island	8,3	1843, 7
12	1855, 1	New Zeland	8,4	1855, 5
13	1868, 8	Peru	9,0	1867, 3

14	1878, 5	Chile	8,3	1878, 12
15	1891, 10	Japan	8,0	1890, 3
16	1902, 4	Guatemala	7,5	1902, 2
17	1903, 4	Turkey	7,0	
18	1906, 12	Italy	7,5	
19	1912, 8	Turkey	7,8	1913, 7
20	1914, 10	Turkey	7,0	
21	1915, 1	Italy	7,0	
22	1920, 12	Kamchatka	8,6	1923, 8
24	1923, 2	China	8,5	
25	1923, 3	China	7,5	1923, 8
26	1923, 9	Japan	7,9	
27	1925, 3	China	7,1	
28	1933, 3	Japan	8,4	1933, 9
29	1933, 8	China	7,4	
30	1934, 1	India	8,1	
31	1935, 4	Taiwan	7,1	
32	1935, 5	Pakistan	7,5	
33	1944, 1	Argentina	7,4	1944, 2
34	1944, 2	Turkey	7,4	
35	1944, 12	Japan	8,0	
36	1945, 1	Japan	7,1	
37	1945, 11	Pakistan	8,0	
38	1953, 3	Turkey	7,3	1954, 5
39	1953, 8	Greece	7,1	

40	1962, 9	Iran	7,1	1964, 10
41	1965, 3	Chile	7,4	
42	1966, 10	Peru	8,1	
43	1975, 2	China	7,0	1976, 6
44	1976, 6	Indonesia	7,1	
45	1976, 2	Guatemala	7,5	
46	1976, 7	China	7,5	
47	1976, 8	Philippines	7,9	
48	1976, 11	Turkey	7,3	
49	1985, 9	Mexico	8,0	1986, 9
50	1987, 3	Columbia	7,0	
51	1995, 5	Sakhalin	7,1	1996, 5
52	1997, 5	Iran	7,3	
53	2003, 12	Iran	6,3	2008,8
54	2004, 12	Indonezia	9,3	
55	2008, 5	China	7,9	
56	2010, 1	Haiti	7,0	
57	2010, 2	Chile	8,8	
58	2011, 3	Japan	9,0	
59	2015, 1	Nepal	7,9	2019, 12 (prognosis)
60	2016, 1, 30	Kamchatka	7,0	
61	2016, 1, 7	Kamchatka	≥7,0	
62	2016, 1, 20			
63	2016, 1	Japan	≥7,0	

64	2016, 1, 19	China	≥7,0	
65	2016, 1, 21	Indonesia	>7,0	
66	2016, 1	USA		
67	2015, 12, 17	Mexico		
68	2016, 1, 19	Peru+Chile		
69	2016, 1, 18	Central America		
70	2016, 1, 6	Mediterranian Sea Region		2019, 12 (prognosis)
71	2016, 1, 22	Iran		
72	2015, 4, 25	India + Pakistan		
73	2015, 5, 12	India + Pakistan		
74	2016, 1, 11	Japan		
75	2016, 1, 14	Japan		
76	2016, 1, 2	China		
77	2016, 1, 30	China		
78	2016, 1, 9	Mexico		
79	2016, 1, 5	Mexico		
80	2016, 1, 21	Mexico		2019, 12 (prognosis)
81	2016, 1, 13	Peru+Chile		
82	2016, 1, 16	Peru+Chile		
83	2016, 1, 8	Peru+Chile		
84	2016, 1, 7	Peru+Chile		
85	2016, 1, 14	Central America		
86	2016, 1, 17	Central America		

Table 1 (continuation). Earthquakes in 2016

Number	Location	Date	Curve Fall	Lead Time	Magnitude
January 2016					
1.	West Indian Region	1	29.12.2015	4	6,3
2.	India	3	29.12.2015	6	6,7
3.	Pacific-Ant. Ridge	5	5	0	6,0
4.	Indonesia	11	10	1	6,5
5.	Japan	11	10	1	6,2
6.	Bolivia	14	10	4	6,1
7.	Japan	14	10	4	6,7
8.	Indonesia	16	10	6	5,6
9.	China	20	10	10	5,9
10.	Mexico	21	10	11	6,6
11.	Alaska	24	24	0	7,1
12.	Morocco	25	24	1	6,3
13.	Papua – New Guinea	26	24	2	6,1
14.	Kamchatka	30	28	2	7,2
15.	near Balley Islands	31	28	3	6,1
February 2016					
16.	New Zeland	1	28.01	4	6,2
17.	Nepal	5	3.02	2	5,2
18.	Taiwan	6	5	1	6,4
19.	Papua – New Guinea	8	5	3	6,4
20.	Chile	10	5	1	6,3
21.	Indonesia	12	12	0	6,3
22.	New Zeland	14	12	2	5,8
23.	Tonga	15	12	3	6,0
24.	East Pasific Rise	16	12	4	6,1
25.	Indonesia	17	12	5	6,0
26.	Chile	22	21	1	6,0
27.	Western Pacific	27	27	0	6,1
March 2016					
28.	Indonesia	2	27.02	4	7,8
29.	Alaska	12	10.03	2	6,3
30.	Alaska	19	17	2	6,0
31.	Antigua + Barbados	19	17	2	6,0
32.	Kamchatka	20	17	3	6,4
April 2016					
33.	Papua – New Guinea	1	28.03	4	6,2
34.	Vanuatu	3	2.04	1	6,2
35.	Vanuatu	6	5	1	6,7
36.	Indonesia	6	5	1	6,1
37.	Vanuatu	7	5	2	6,7
38.	Nepal	9	9	0	4,1
39.	Afghanistan	10	9	1	6,6
40.	Myanmar	13	9	4	6,9
41.	Philippines	13	9	4	6,0

42.	Japan	14	14	0	6,2
43.	Japan	14	14	0	6,0
44.	Vanuatu	14	14	0	6,4
45.	Guatemala	15	14	1	6,1
46.	Japan	15	14	1	7,0
47.	Ecuador	16	14	2	7,5
48.	South Georgia and South Sandwich Islands	19	14	5	6,2
49.	Ecuador	20	14	6	6,2
50.	Ecuador	22	14	8	6,0
51.	Mexico	25	21	4	6,0
52.	Mexico	27	21	6	6,0
53.	Vanuatu	28	21	7	7,0
54.	Clipperton Islands	29	28	1	6,6
May 2016					
55.	China, Tibet	11	6	5	5,2
56.	Ecuador	18	15	3	6,7
57.	Ecuador	18	15	3	6,9
58.	Australia	20	20	0	6,0
59.	Fiji	27	23	4	6,4
60.	Fiji	28	27	1	6,9
61.	South Georgia and South Sandwich Islands	28	27	1	7,2
62.	Algeria	29	29	0	5,4
63.	Taiwan	31	29	2	6,4
June 2016					
64.	Indonesia	1	29.05	3	6,6
65.	Indonesia	5	2.06	3	6,3
66.	New Zeland	6	2	4	6,1
67.	Mexico	7	2	5	6,3
68.	Indonesia	7	2	5	6,3
69.	Indonesia	9	2	7	6,1
70.	Nicaragua	10	2	8	6,1
71.	Solomon Islands	10	2	8	6,2
72.	Vanuatu	14	12	2	6,3
73.	Vanuatu	15	15	4	6,3
74.	Vanuatu	20	20	0	6,0
75.	Northern Mid – Atlantic Ridge	21	20	1	6,1
76.	Papua – New Guinea	24	23	1	6,3
77.	Kyrgyzstan	26	25	1	6,4
78.	Vanuatu	30	25	5	6,0
July 2016					
79.	Tonga	10	10	0	6,0
80.	Ecuador	11	10	1	6,3
81.	New Zeland	13	12	1	6,3
82.	Vanuatu	20	19	1	6,1
83.	Chile	25	19	6	6,1
84.	Papua New Guinea	25	19	6	6,4
85.	Northern Mariana Islands	29	25	4	7,7
August 2016					

86.	Azerbaijan	1	31.07	1	5,0
87.	Argentina	4	3.08	1	6,2
88.	Japan	4	3	1	6,3
89.	New Caledonia	12	11	1	7,2
90.	Tonga	12	11	1	6,1
91.	Peru	15	13	2	5,5
92.	Australia	18	17	1	5,7
93.	East Pacific Rise	18	17	1	6,0
94.	South Georgia and South Sandwich Islands	19	17	2	7,4
95.	Indonesia	23	21	2	6,0
96.	East Nusa Tenggara	23	21	2	6,2
97.	Italy	24	21	3	6,2
98.	Myanmar	24	21	3	6,8
99.	Ascension Islands	29	29	0	7,1
100.	Papua – New Guinea	31	29	2	6,8
September 2016					
101.	New Zeland	1	29.08	3	7,0
102.	New Zeland	1	29.08	3	6,1
103.	Oklahoma, USA	3	2.09	1	5,8
104.	Ecuador	5	2	3	4,7
105.	Pakistan	5	2	3	4,7
106.	Kamchatka	5	2	3	6,1
107.	Australia	8	8	0	6,1
108.	Peru	10	8	2	6,1
109.	Tanzania	10	8	2	5,9
110.	Macedonia	11	8	3	5,1
111.	South Korea	12	8	4	5,4
112.	Colombia	14	11	3	6,0
113.	Solomon Islands	14	11	3	6,0
114.	Indonesia	17	15	2	6,0
115.	Japan	20	20	0	6,1
116.	Pakistan	22	20	2	4,9
117.	Japan	23	22	1	6,2
118.	Burundi	23	22	1	4,8
119.	Romania	23	22	1	5,6
120.	Philippines	24	24	0	6,3
121.	Tonga	24	24	0	6,4
122.	Fiji	24	24	0	6,9
123.	Nicaragua	28	27	1	5,5
October 2016					
124.	Pakistan	1	29.09	2	5,4
125.	Papua – New Guinea	15	15.10	0	6,3
126.	Greece	15	15	0	5,5
127.	Peru	16	15	1	5,0
128.	Papua – New Guinea	17	15	2	6,8
129.	China	17	15	2	5,9
130.	Indonesia	19	15	4	6,6
131.	Japan	21	20	1	6,2
132.	Tonga	26	25	1	6,1

133.	Italy	26	24	2	6,1
134.	Chile	27	25	2	6,0
135.	Italy	30	29	1	6,6
136.	Colombia	31	29	2	5,6
November 2016					
137.	Papua – New Guinea	1	1	0	6,0
138.	Chile	4	2	2	6,3
139.	Oklahoma, USA	7	4	3	5,0
140.	Chile	8	4	4	6,0
141.	Japan	11	8	3	6,1
142.	New Zeland	13	12	1	7,8
143.	New Zeland	13	12	1	6,5
144.	New Zeland	13	12	1	6,1
145.	New Zeland	13	12	1	6,2
146.	New Zeland	14	12	2	6,5
147.	Argentina	20	19	1	6,5
148.	Japan	22	20	2	6,9
149.	El Salvador	24	21	3	7,0
150.	China	25	21	4	6,6
151.	Nepal	27	21	6	5,4
152.	Poland	29	21	8	4,4
December 2016					
153.	Costa Rica	1	21.11	10	5,2
154.	Peru	1	21.11	10	6,2
155.	Indonesia	5	3.12	2	6,3
156.	Indonesia	6	3	3	6,5
157.	China	8	3	5	6,0
158.	California	8	3	5	6,5
159.	Solomon Islands	8	3	5	7,8
160.	Solomon Islands	8	3	5	6,5
161.	Croatia	9	8	1	4,4
162.	Solomon Islands	9	8	1	6,9
163.	Papua – New Guinea	10	8	2	6,1
164.	Northern Marian Islands, USA	14	10	4	6,0
165.	Papua – New Guinea	17	15	2	7,9
166.	Papua – New Guinea	17	15	2	6,3
167.	Solomon Islands	18	15	3	6,0
168.	Micronesia	18	15	3	6,2
169.	Peru	18	15	3	6,4
170.	Ecuador	19	15	4	5,4
171.	Solomon Islands	20	19	1	6,4
172.	Indonesia	21	19	2	6,7
173.	Chile	25	22	3	7,6
174.	Japan	28	23	5	5,9
175.	Indonesia	29	28	1	6,2

Table 2. **Volcanic eruptions**

Numbers	**Date**	**Location**	**Name**	**Solar min (year, month)**
1	79, 8, 24	Italy	Vezuvii	79
2	1600	Peru	Huaynaputina	1598
3	1687	Mexico	Orisaba	1684
4	1702	China	Changbaishan	1698
5	1728	Ecuador	Sangai	1723
6	1738	Ecuador	Cotopashi	1734
7	1766, 10	Philippines		1766
8	1810, 4	Indonesia	Tambora	1810, 12
9	1854	USA	Reniz	1855, 9
10	1877	Chile	Lulyalyaco	1878, 8
11	1883, 7	Indonesia	Krakatau	
12	1902, 2	Guatemala		1902, 4
13	1902, 5	Guadeloupe		1902, 4
14	1912, 6	Alaska	Novarupta	1912,2
15	1922	Guatemala	St.-Maria	1923, 8
16	1931, 12	Indonesia	Merani	1933, 8
17	1972	Kamchatka	Klyuchevskaya sopka	1976, 6
18	1974	Kamchatka	Klyuchevskaya sopka	1976, 7

19	1975	Ecuador	Sangai	1976, 7
20	1976	Ecuador	Cotopashi	1976, 7
21	1984	Hawaii, USA	Mauna Loa	1986,6
22	1985, 11	Columbia	Ruis	1985,9
23	1991, 6	Philippines	Pinatubo	1996,10
24	1997, 6	Philippines	Pinatubo	1996,10
25	1999, 2	Guadeloupe	Safries	1996,10
26	1999, 2	Guatemala	St.-Maria	1996,10
27	2002, 1	Congo	Nyiratongo	1996,10
28	2002, 2	USA	Redault	1996,10
29	2002, 9	Italy	Etna	1996,10
30	2004	Italy	Etna	2008, 8
31	2006, 5	Indonesia	Merani	2008, 8
32	2006, 6	Indonesia	Merani	2008, 8
33	2007	Italy	Etna	2008, 8
34	2008	Italy	Etna	2008, 8
35	2010, 4	Iceland	Gecla	2008, 8
36	2010, 8	Guatemala	Pakaya	2008, 8
37	2010, 10	Indonesia	Merani	2008, 8
38	2010, 10	Ecuador	Tungurauya	2008, 8
39	2010	Kamchatka	Klyuchevskaya sopka	2008, 8
40	2010, 2	Guadeloupe	Sufrier	2008, 8
41	2011	Italy	Etna	2008, 8
42	2011, 5	Iceland	Gecla	2008, 8

43	2011, 6	Chile	Fuegue	2008, 8
44	2013, 9	Indonesia	Rokatenda	2008, 8A
45	2014, 3	Mexico	15 eruptions	2019, 12 (prognosis)
46	2014, 10	Japan	Outake	2019, 12 (prognosis)
47	2015, 12	Kamchatka	Shiveluch	2019, 12 (prognosis)
48	2015, 12	Nicaragua	Momotombo	2019, 12 (prognosis)
49	2015, 12	Italy	Etna	2019, 12 (prognosis)
50	2015, 12	Philippines	Kaulaon	2019, 12 (prognosis)
51	2015, 12	Guatemala	Fuegu	2019, 12 (prognosis)
52	2015, 12	Kamchatka	Shiveluch	2019, 12

Table 2 (continuation). Volcanic eruptions on 2016

N	Month	Date	Name	Zone
1.	January	4	Fuego	Guatemala
2.		5	Mount Bromo	Indonesia
3.		5	Mount Soputan	Indonesia
4.		17	Angahuan	Mexico
5.	February	5	Mount Sakurajima	Japan
6.		27	Huambalo	Ecuador
7.		27	Erta Ale	Ethiopia
8.	March	5	Huambalo	Ecuador
9.		27	Pavlov Volcano	Alaska
10.	April	4	Villarrica	Chile
11.		21	Nyiragongo	Congo
12.	May	24	Mount Sinabung	Indonesia
13.	June	15	Kawah Ijen	Indonesia
14.		23	Kilauea	Hawaii

15.		29	Kilauea	Hawaii
16.	July	12	Mount Bromo	Indonesia
17.		23	Kilauea	Hawaii
18.	August	8	Kilauea	Hawaii
19	September	11	Peak of Furnance	La Reunion
20.		24	Cerro Negro	Nicaragua
21		28	Kilauea	Hawaii
22.		30	Kilauea	Hawaii
23.	October	20	Rosario Island	Japan
24.		31	Mount Sinabung	Indonesia
25.	November	21	Nevado del Tolima	Colombia

Table 3

Solar activity and earthquakes

Cycle	**Solar min**	**Kamchat. Sakhalin Kuril**	**Japan**	**China**	**Indonesia**	**Alaska Californ**	**Mexico**	**Peru**	**Chile**	**Central America**	**Mediter. Sea region**	**Turkey**	**Iran**
1	1755												1755
4	1784												
5	1796									1797			
6	1810									1812			
7	1823							1821					
8	1833				1833				1835				
9	1843												
10	1855					1857							
11	1867							1868					
12	1878					1881			1877	1875			
13	1890		1891 1896									1894	
14	1902					1901		1897 1908		1902	1903 1905 1908	1903	
15	1913		1911	1910 1917		1906 1914	1907 1911		1906	1906	1915	1912 1914	1909
16	1923	1923	1923 1927	1918 1920 1923 1925 1927		1922			1922				
17	1933		1933	1931 1932	1938	1933 1934	1931 1932		1928				1929 1930

				1933									
18	1944		1943 1944 1945 1946 1948	1948				1940 1942 1946 1947 1948	1943	1942 1946		1939 1942 1943 1944	1947
19	1954	1958	1952	1950		1957,3 1957 1953	1957	1953 1958			1953 1954	1953 1957	1957
20	1964	1963	1964 1968	1959 1966		1964,3,28 1965 1966	1962 1965 1968	1960 1970	1960 1965 1971	1969 1970	1965	1964 1967	1962 1968
21	1976			1972 1975 1976,7,28	1976	1971		1974		1974 1976 1979	1980	1976	1972 1978
22	1986					1983 1987	1985		1985	1987		1983	1981 1990
23	1990	1995 1997 2002		1998 1999 2002	1992 2000 2002	2004,4 2012	1996 1999	1998 2001	1998 2001	1991 1992 1994 1997 1998 2001		1999	1997
24	2008	2006 2009 2016,1,7 2016,1,2	2003 2004 2005 2008 2009 2011 2013	2006 2008 2013 2014 2015 2016,1,19	2003 2004 2005 2006 2007 2008 2009	2013 2014,3 2014,3,1 2016,1,2	2003 2012,3,21 2014 2015,12,17 2016,1,8	2005 2007 2010 2012 2014 2015 2016,1	2005 2007 2010 2012 2014 2015 2016,1	2004 2009 2010 2012 2013 2014 2016,1	2012,5,2 2014 2016,1,6	2016,12	2013 2016,1,22

			2014 2015 2016,1,9 2016,1,5 2016,1.11 2016,1,14	2016,1,13 2016,1.2 2016,1,20	2010 2012,4,11 2013 2014 2015 2016,1,2 2016,1,1 2016,1,1 2016,1,1 2016,1,1 2016,1,8 2016,1,1 2016,1,2 2016,1,1 2016,1,1 2016,1		2016,1,6 2016,1,21 2016,1,5	,19 2016,1,20 2016,1,13 2016,1,8 2016,1,7	,19 2016,1,20 2016,1,13 2016,1,16 2016,1,8 2016,1,16 2016,1,7	,1 2016,1,3 2016,1,1			

					,1 2016,1 ,2								
25	2019												

Table 4. Solar activity, earthquakes and volcanic eruptions on 2017

Earthquakes Volcanic eruptions

	SSp	Location	Magni-tude	Depth (km)	Location	Name
January						
1	12					
2	0	Tonga	6,3	551,6		
3	0	India	5,7	32,0		
		Fiji	6,9	12,0		
4	0	Fiji	6,0	10,0	Costa Rica	Turrialba
5	0				Costa Rica	Turrialba
6	0	Iran	5,0	10,0		
7	0					
8	0	Canada	6,0	31,0		
9	0					
10	0	Philippines	7,3	627,2		
		Solomon Islands	6,3	26,0		
11	0	Madagascar	5,5	7,3		
12	11					
13	27					
14	31					
15	28					
16	24	Indonesia	5,6	6,0		
17	32					
18	36	Italy	5,7	7,0		
		Italy	5,6	10,0		
19	33	Solomon Islands	6,5	36,0		
20	55				Mexico	Colima
21	75				Alaska	Bogoslov
22	71	Papua-New Guinea	7,5	185,0		
23	59					
24	43					

25	46					
26	41					
27	27					
28	29					
29	32					
30	33				Mexico	Colima
31	–					
February						
1	35					
2	42					
3	34	France	5,8	44,0		
4	11					
5	15					
6	12	Turkey	5,2	7,2	Azerbaijan	Otman Bozdag
		Colombia	8,5	38,0		
		India	5,1	16,1		
7	12	Pakistan	6,3	24,1		
8	0	China	4,9	10,0		
9	20				Ethiopia	Erta Ale
10	21	Philippines	6,5	15,0		
		Taiwan	5,3	15,8	Kamchatka	3 volcanoes
11	20					
12	17					
13	16					
14	16				Reunion, France	Piton-de-la-Farnez
15	23	Indonesia	5,4	13,8	Italy	Campi Flegrey
		Indonesia	5,0	38,6		
16	12					
17	13					
18	12	Argentina	6,3	222,0	Australia	Mouson
19	22					
20	33					
21	17	Bolivia	6,5	596,0	Kamchatka	3 volcanoes
22	16					
23	21	Philippines	4,6	15,6		
24	12	Zambia	5,9	30,0		
		Tonga	6,9	414,9		
25	30				Guatemala	Fuego
26	31					
27	45					

28	–					
March						
1	57					
2	54	Turkey	5,6	10,0		
3	40					
4	0					
5	12	Philippines	5,7	10,2		
		Papua-New Guinea	6,3	31,1		
6	0					
7	0					
8	0					
9	0				Kamchatka	Kluchevskay
10	0					
11	0				Mexico	Popocatepetl
12	0				Mexico	Popocatepetl
13	0	Myanmar	5,1	10,0		
14	0	India	6,0	10,0		
		Kyrgizstan	5,5			
15	0				Italy	Etna
16	0					
17	0					
18	0					
19	0	Solomon Islands	6,2			
		Myanmar	5,1			
20	0	Solomon Islands	5,1; 6,2		Peru	
		Kamchatka	5,1			
		India	5,9			
		Indonesia	6,0			
21	12					
22	13					
23	14					
24	13				Kamchatka	Kambalnyj
25	16					
26	27					
27	48					
28	55				Italy, Costa Rica	Etna, Turrialba
29	48					
30	47				Costa Rica	Turrialba
31	–				Guatemala	Fuego

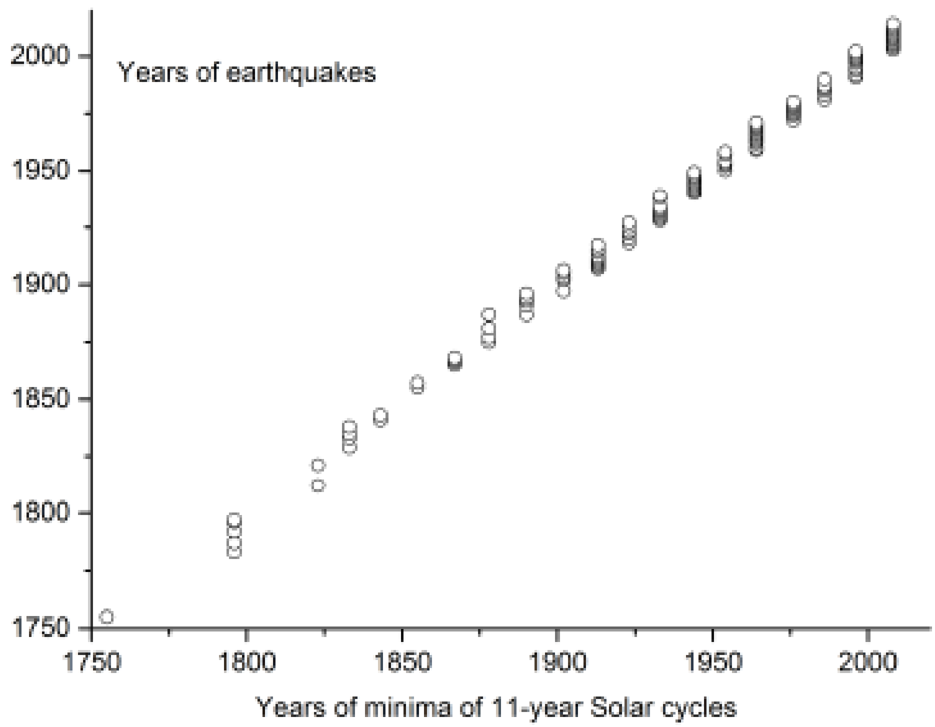
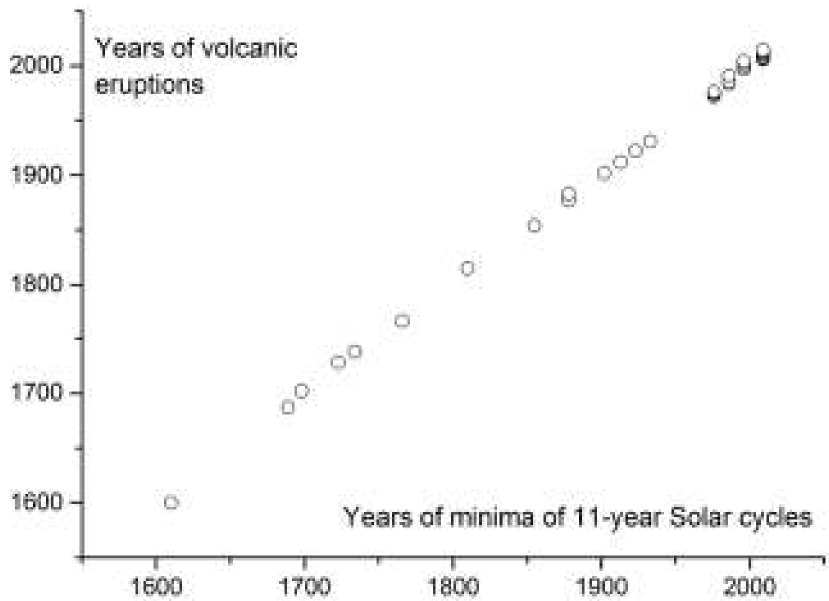


Fig 1. Comparison of years of earthquakes with years of solar minimum

Fig 2. Comparison of volcanic eruptions years with years of solar minimum.



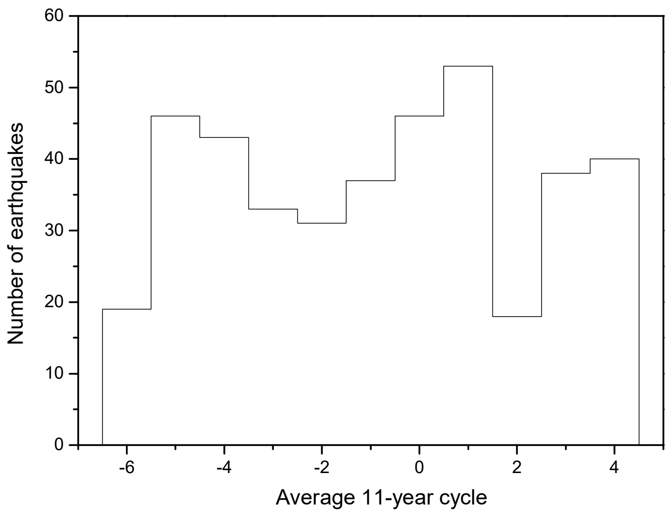
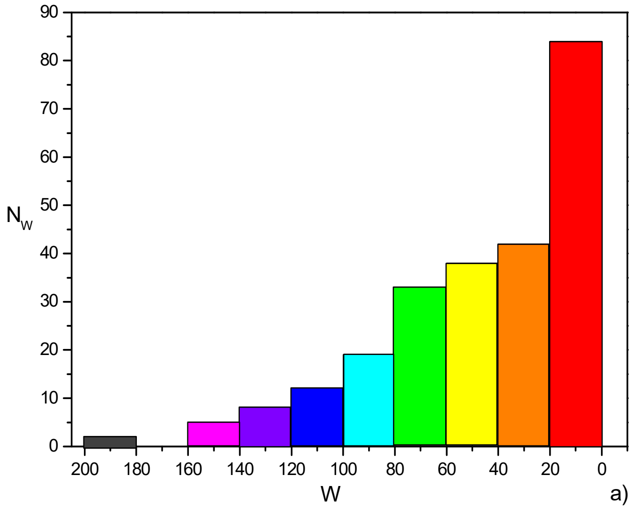
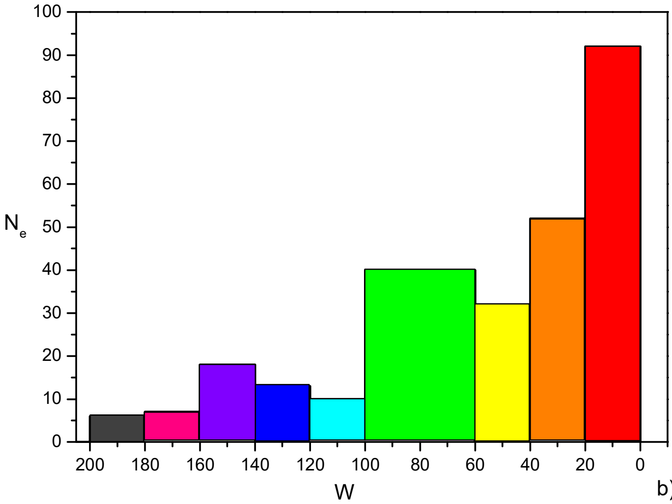


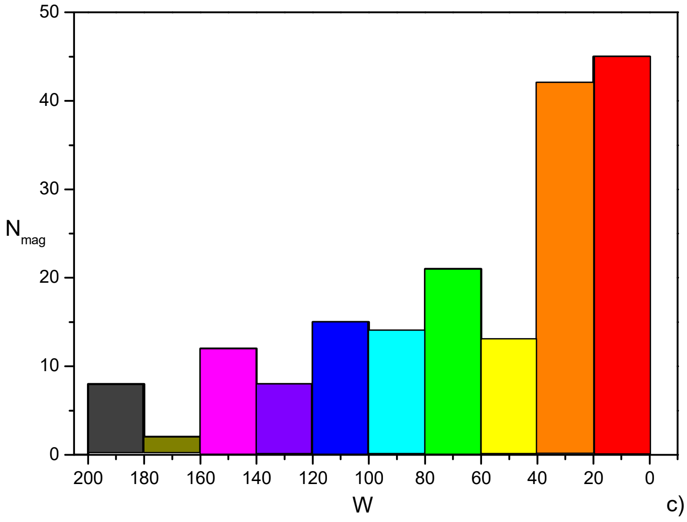
Fig 3. Number of earthquakes as a function of the number of years from the minima of solar minima (zero corresponds to the minima of Solar activity). The graf is constructed by superposition of different epochs of solar activity.



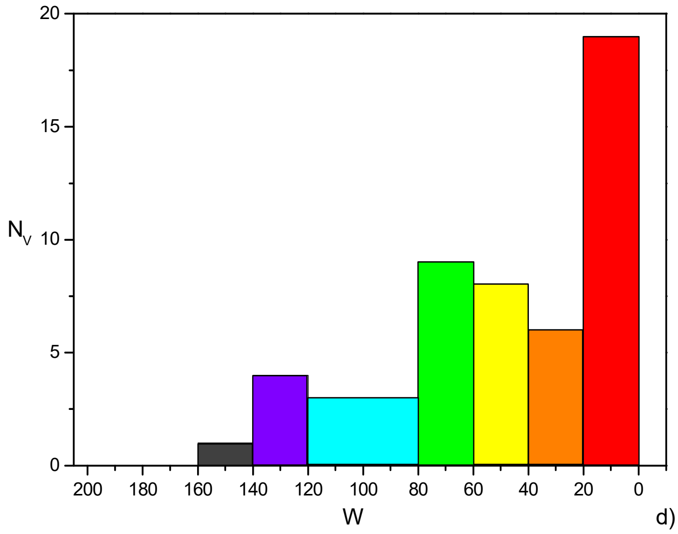
a) Freguency distribution of W.



b) Earthquakes as function of W.



c) Earthquakes magnitude as function of W.



d) Number of volcanic eruptions as function of W.

Fig. 4. Frequency distribution of W (a)

Number of earthquakes as function of W (b)

Earthquakes magnitude as function of W (c)

Number of volcanic eruptions as function of W (d)

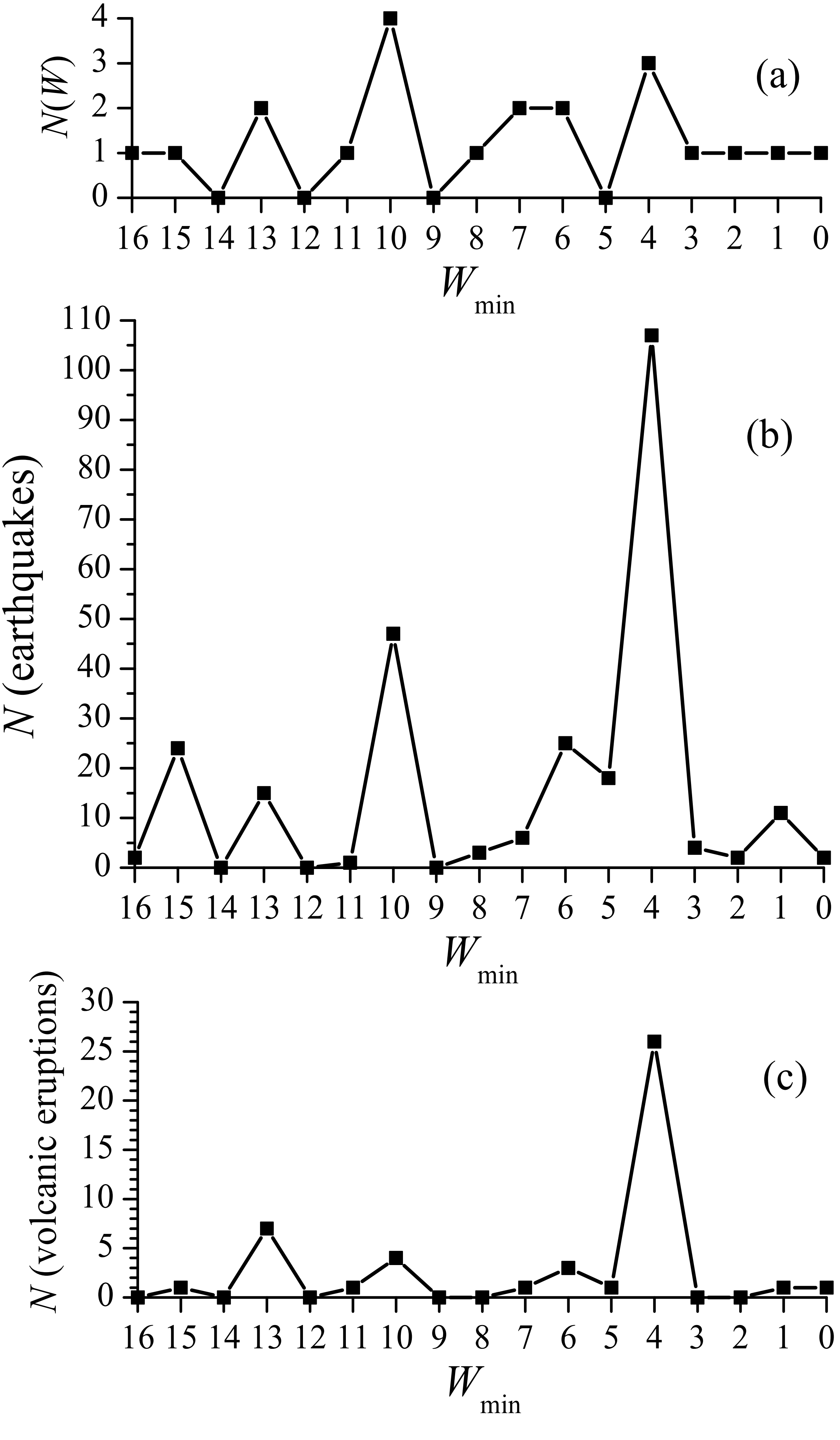

(a)
N(W)
4
3
2
1
0
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
W min
(b)
N (earthquakes)
110
100
90
80
70
60
50
40
30
20
10
0
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
W min
(c)
N (volcanic eruptions)
30
25
20
15
10
5
0
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
W min

Fig. 5 (explanation see in text)

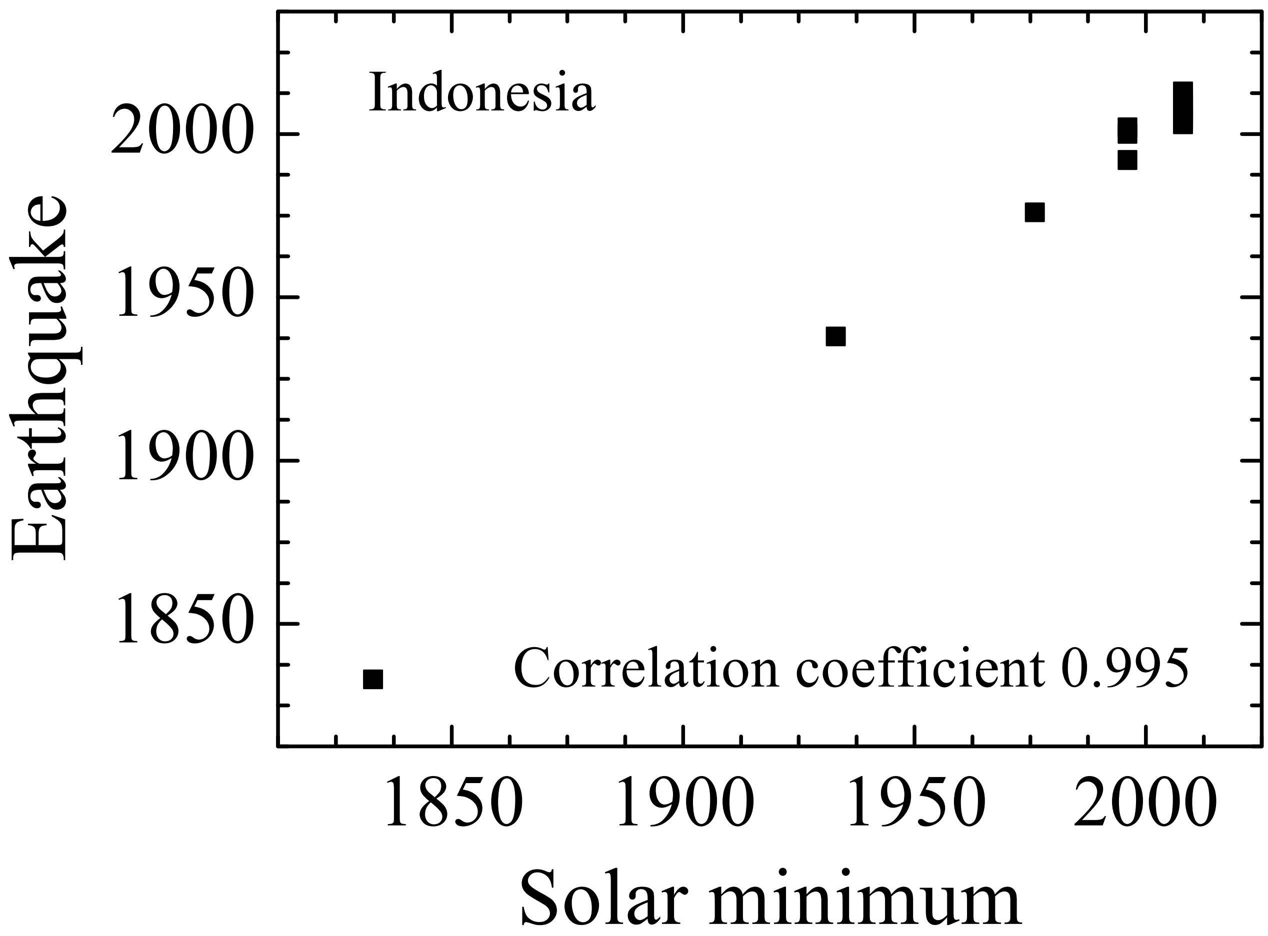


Fig. 6 Comparison of years of earthquakes with years of solar minimum for Indonesia

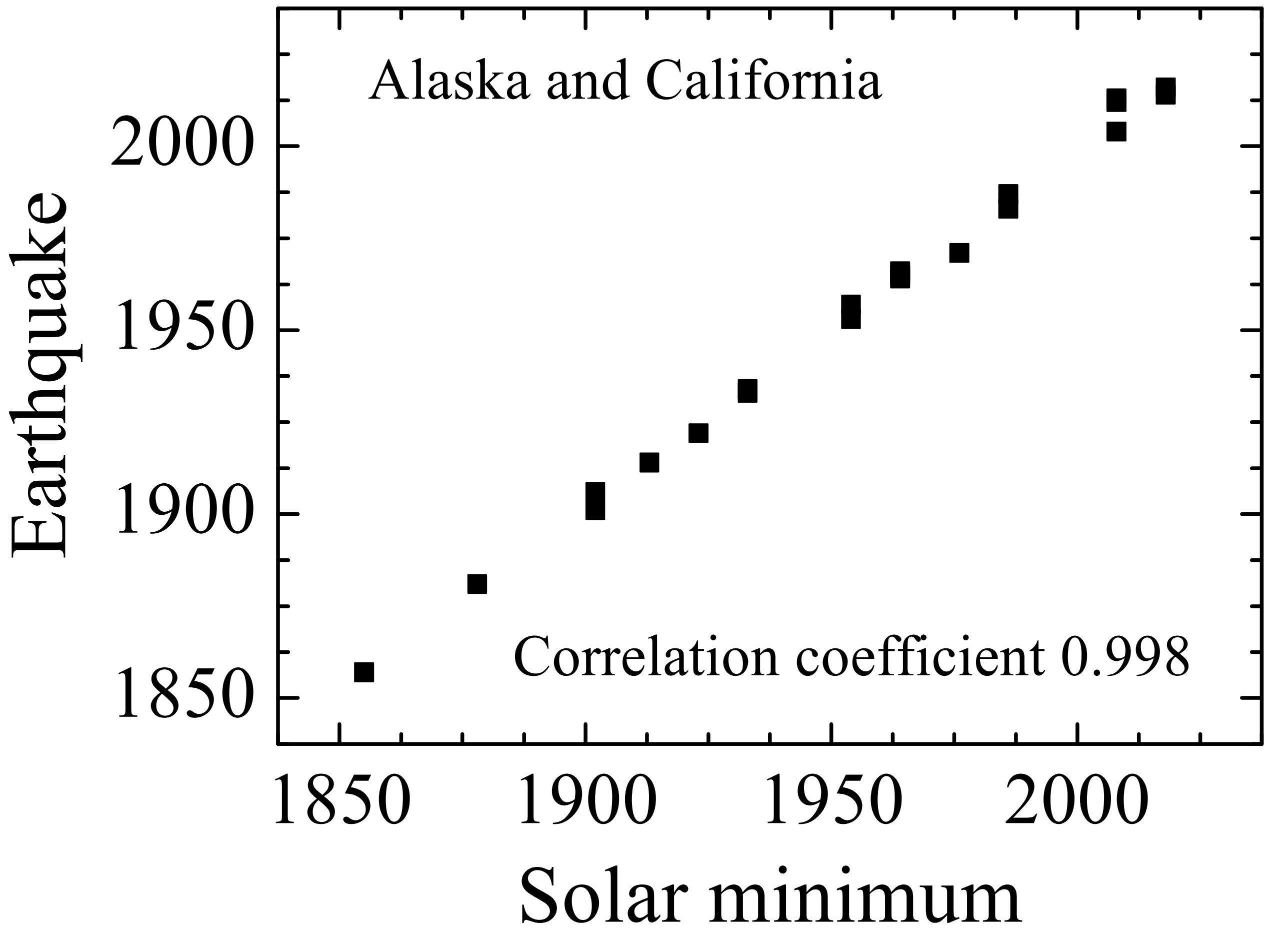


Fig. 7 The same as in Fig.6 for Alaska and California

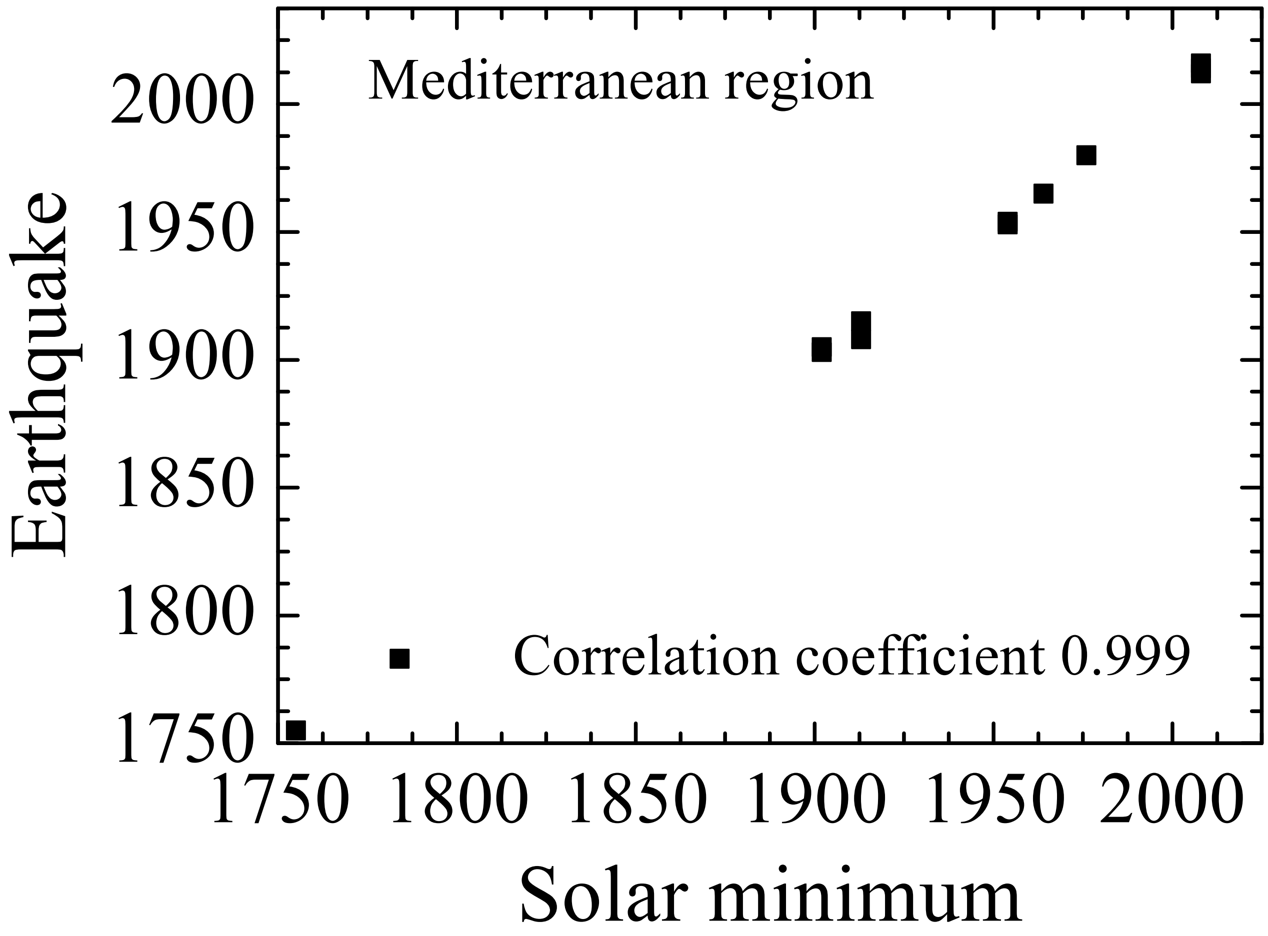


Fig. 8 The same as in last Fig’s for Mediterranean region

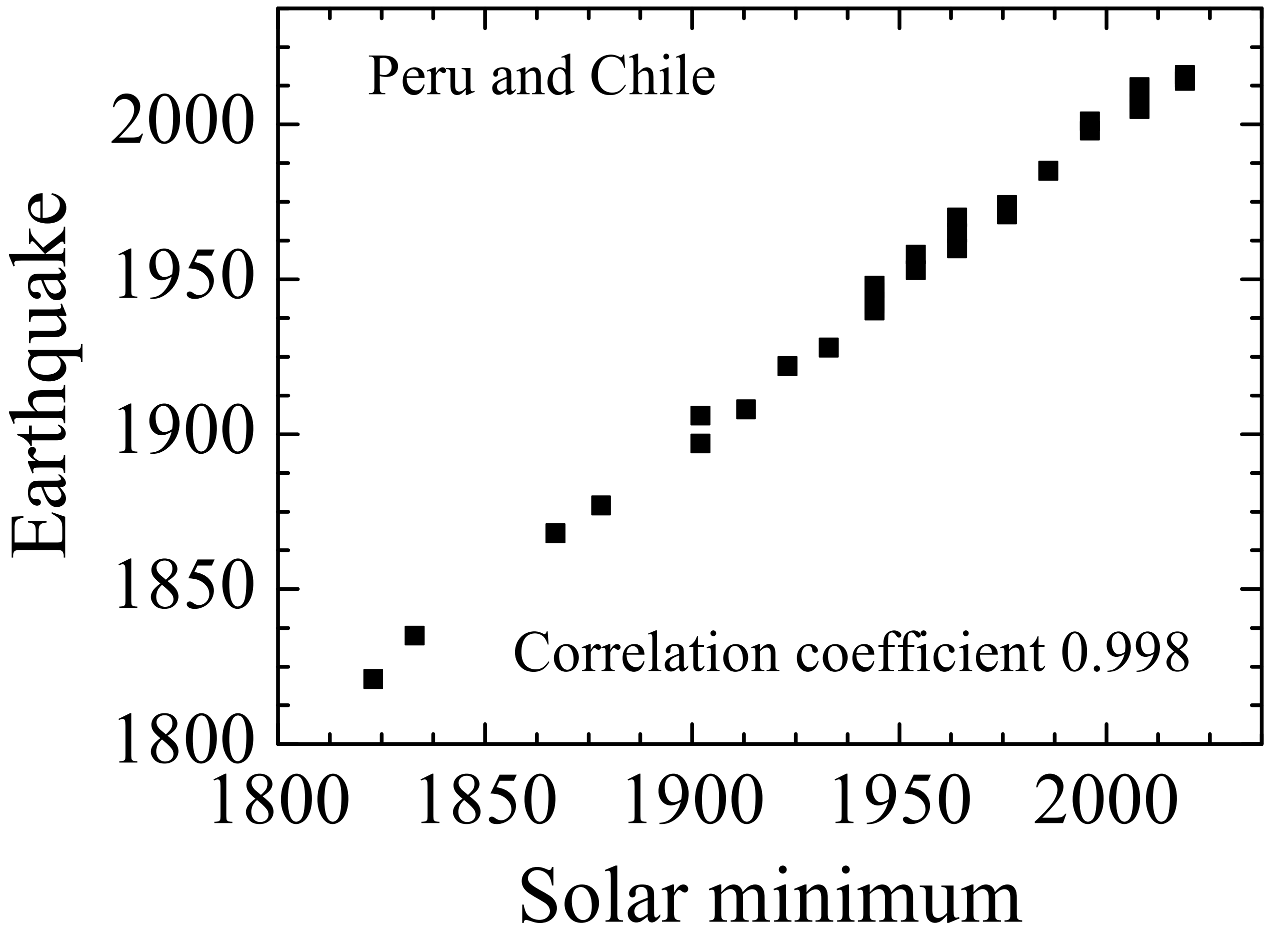


Fig. 9 The same as in Fig.6-8 for Peru and Chile

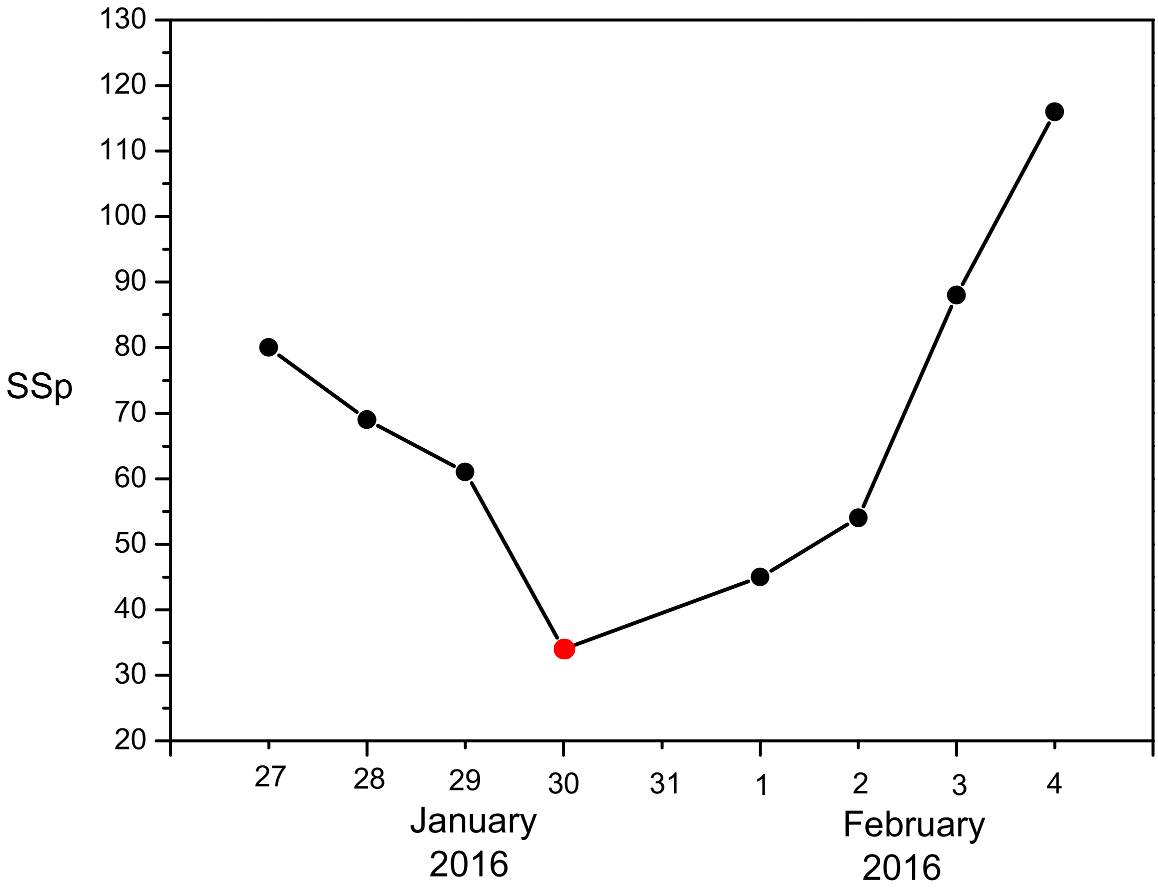


Fig. 10 Earthquake in Kamchatka, January 30, 2016

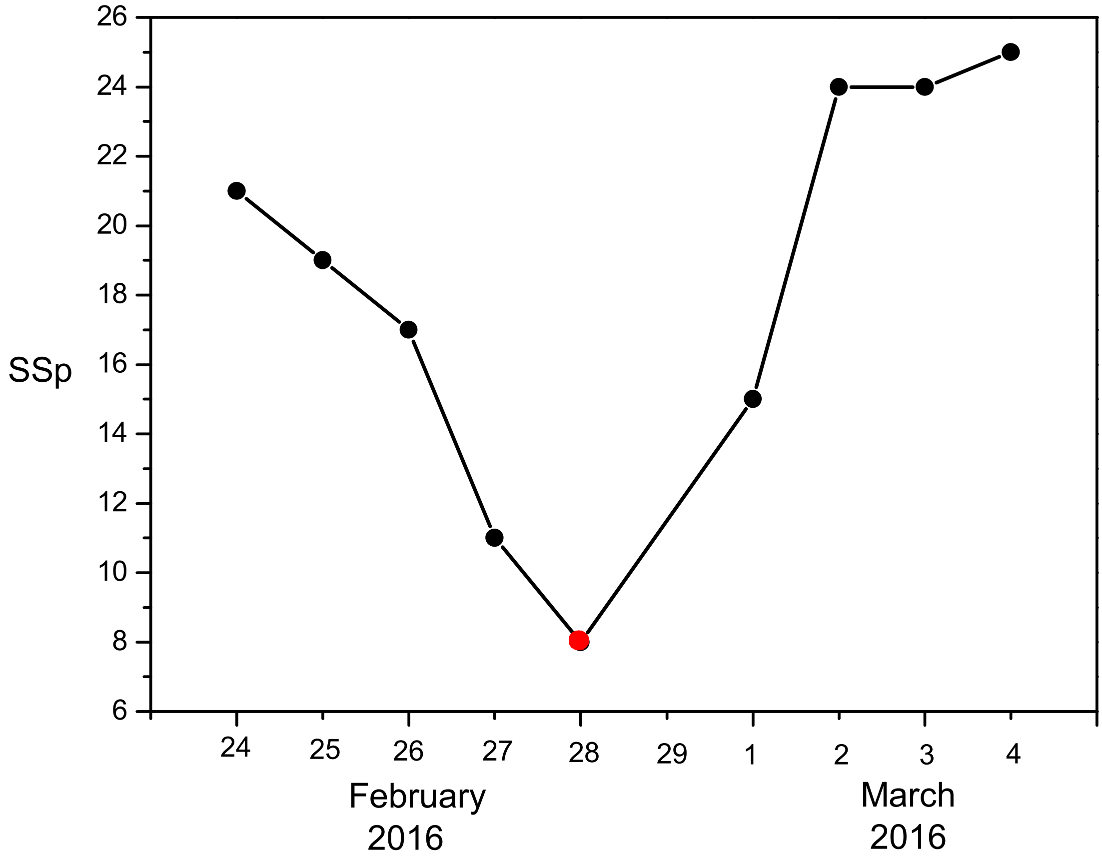


Fig. 11. February 2016 – March 2016

The same as in Fig.10. Earthquake in Sumatra in March 2, 2016

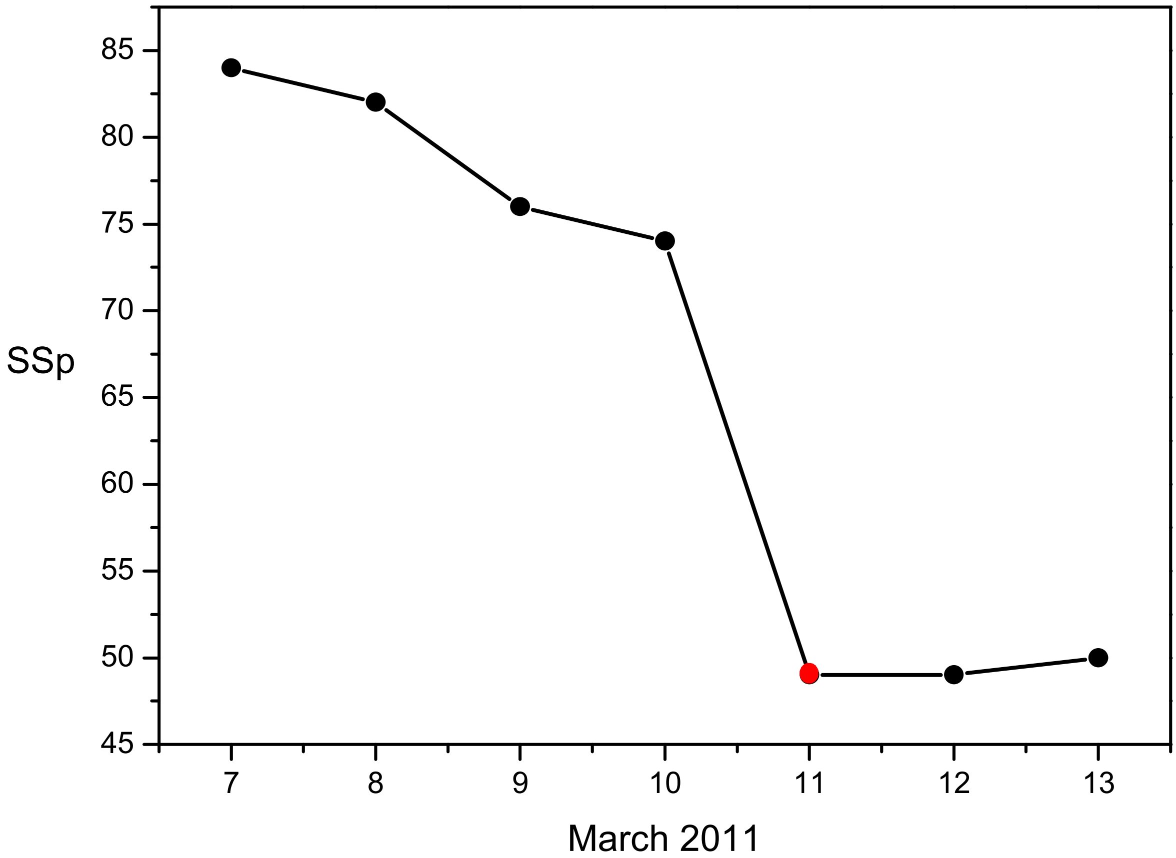


Fig. 12. The same as in Fig 10. Earthquake in Japan: March, 11, 2011

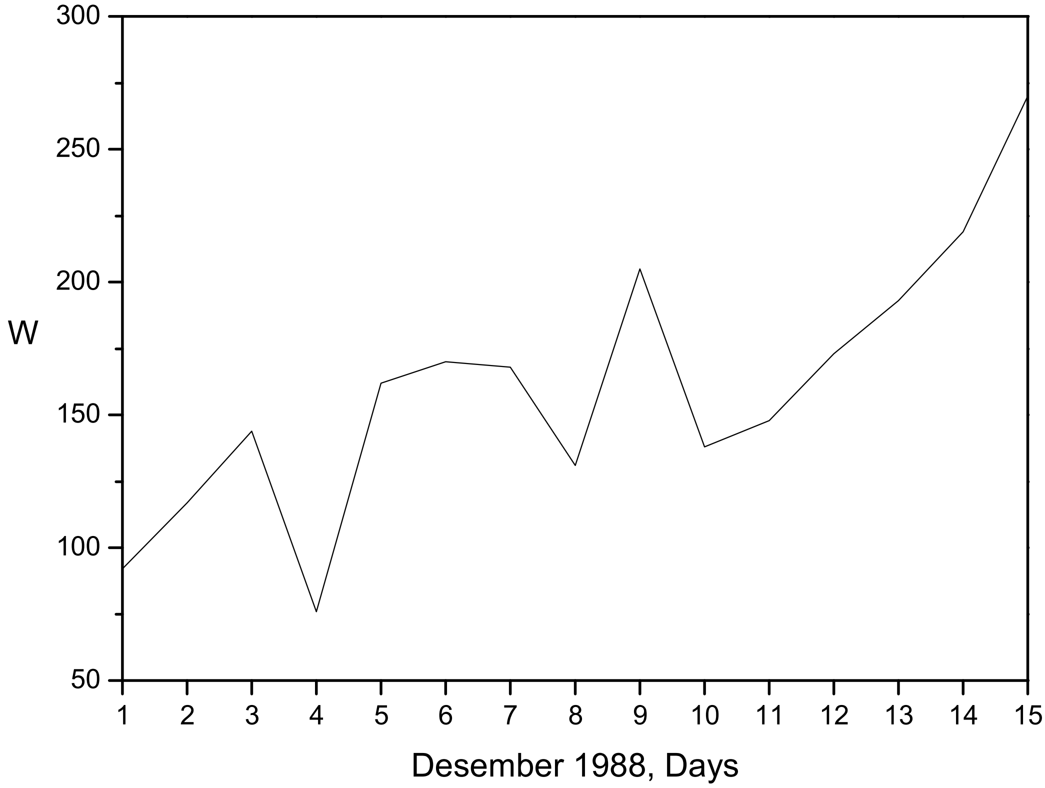


Fig. 13 Earthquake in Armenia, December 7, 1988.

In Fig. 14-55 there are daily solar activity indexes SSp on sun days before an earthquake and some days after it. Dates of earthquakes are marked by circles

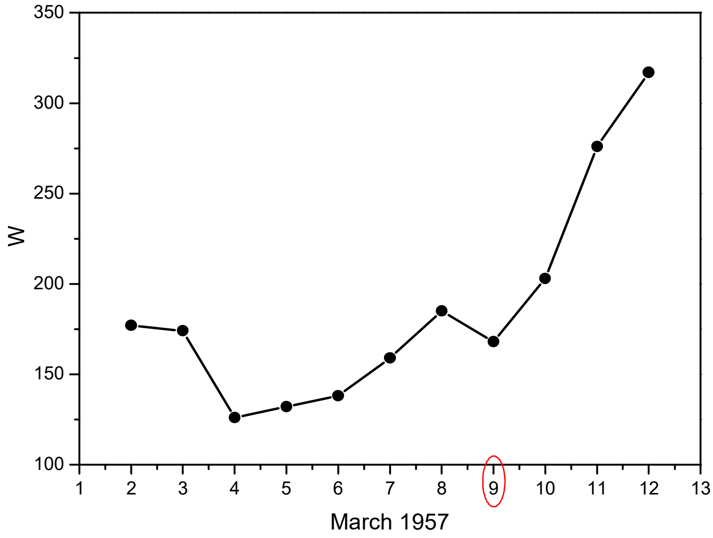


Fig. 14. Alaska, March 9, 1957

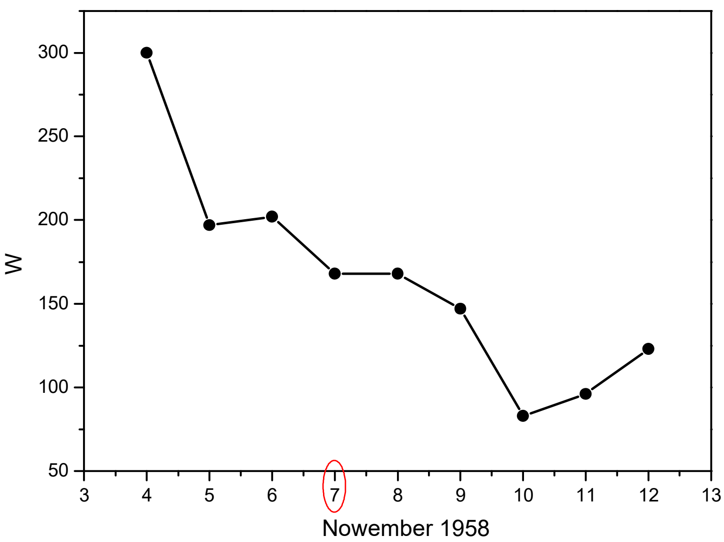


Fig. 15. Kuril, November 7, 1958

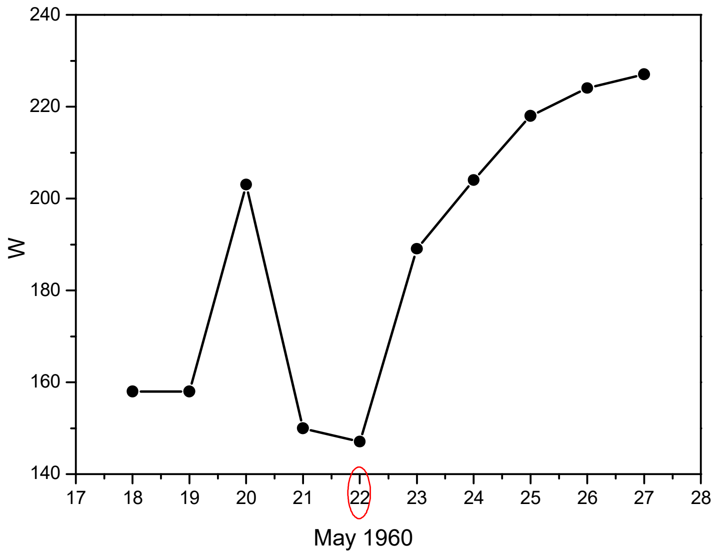


Fig. 16. Chile, May 22, 1960

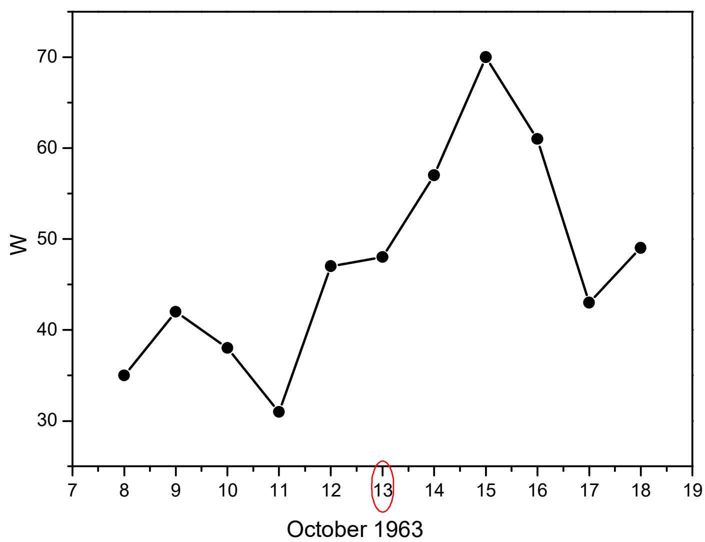
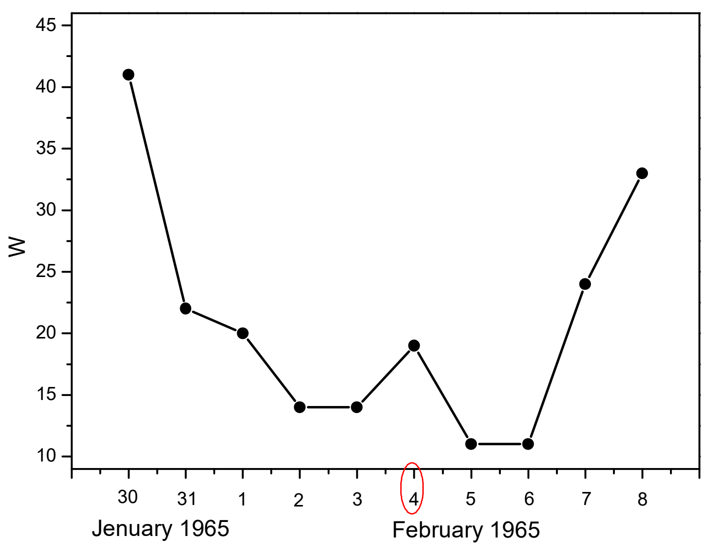


Fig. 17. Kuril, October 13, 1963



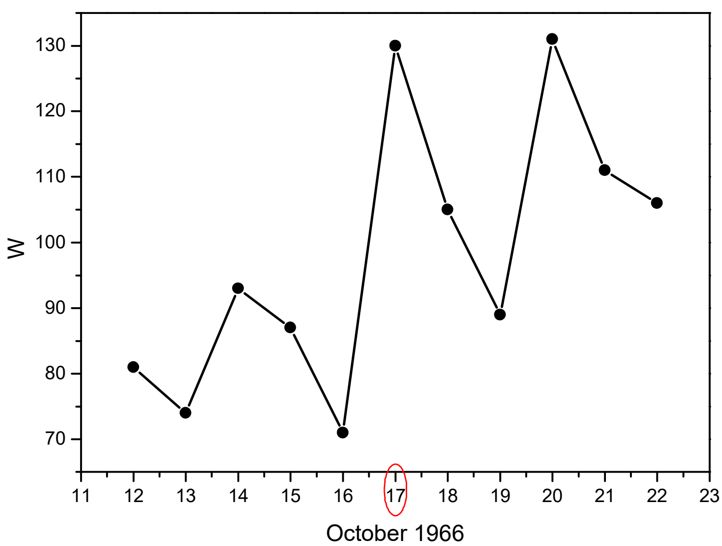


Fig. 18 Alaska, February 4, 1965

Fig. 19. Peru, October 17, 1966

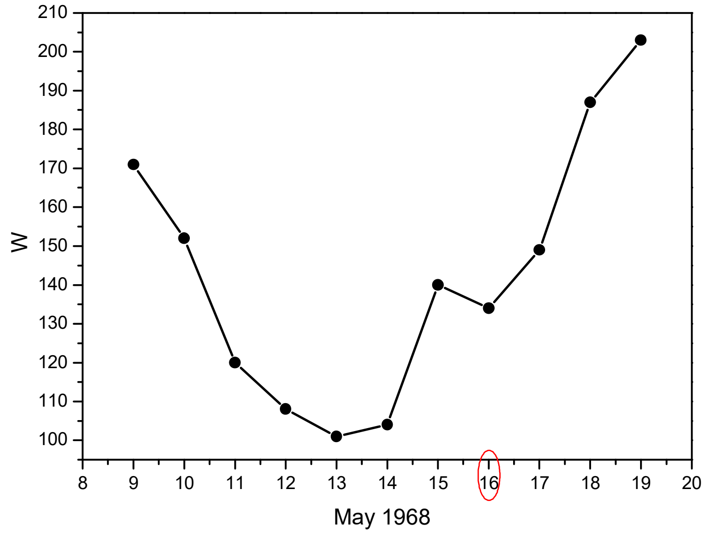


Fig. 20. Japan, May 16, 1968

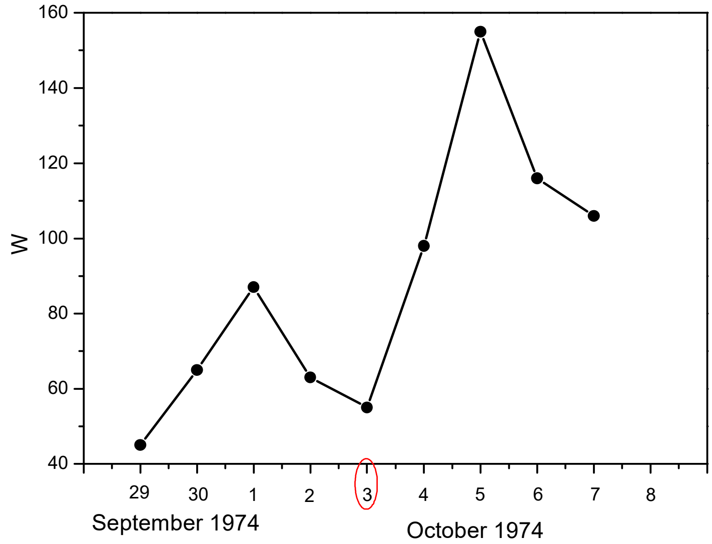


Fig. 21. Peru, October 3, 1974

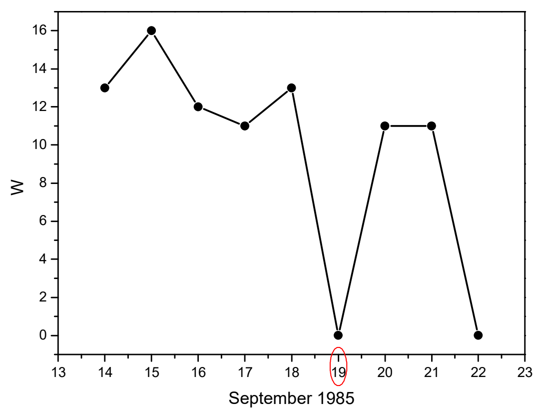


Fig. 22. Mexico, September 19, 1985

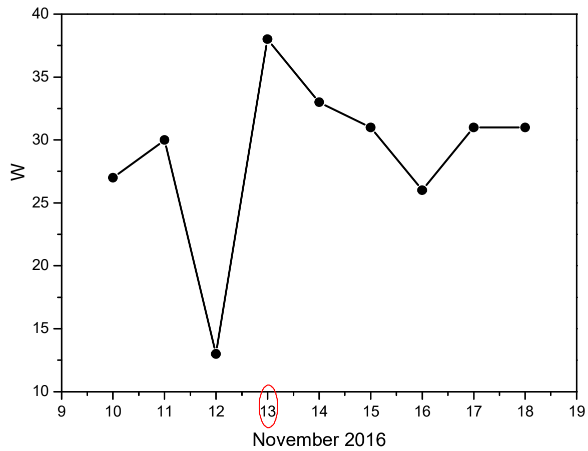


Fig. 23. New Zeland, November 13, 2016

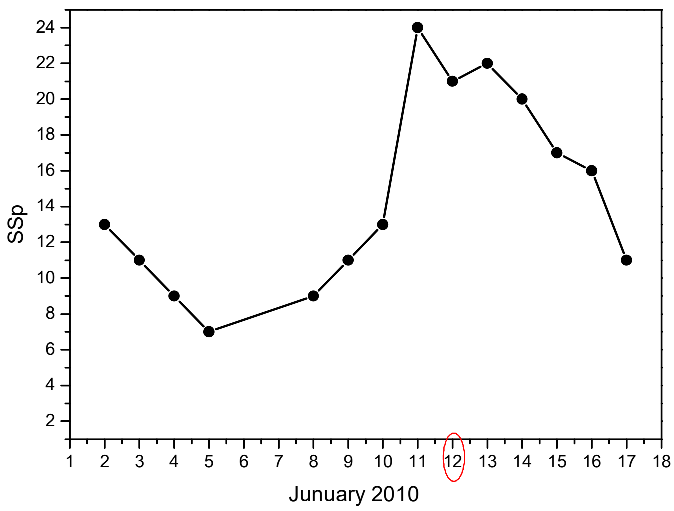


Fig. 24. Haiti, Junuary 12, 2010

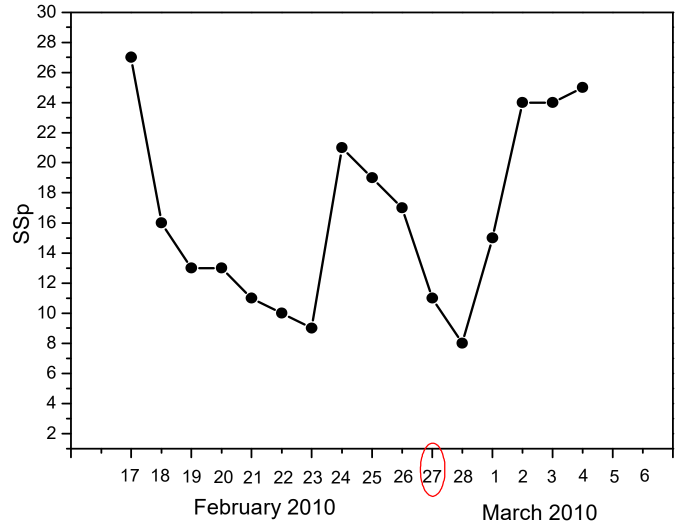


Fig. 25. Chile, February 27, 2010

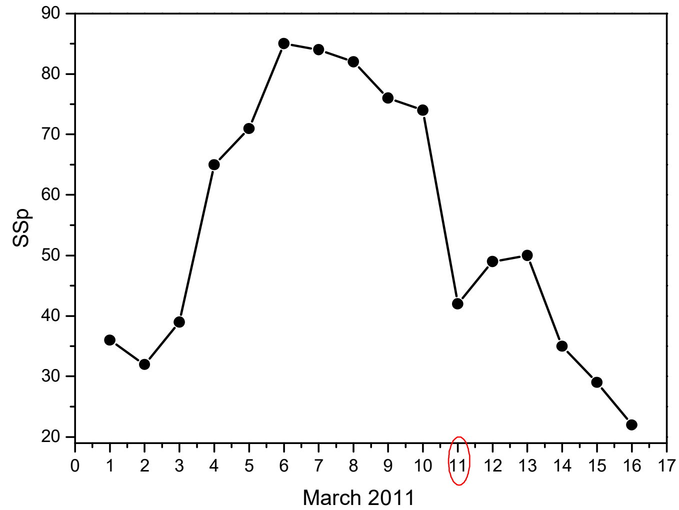


Fig. 26. Japan, March 11, 2011

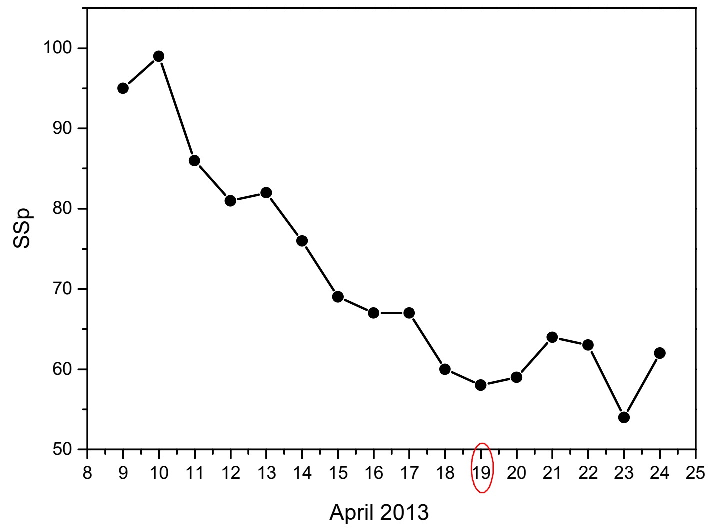
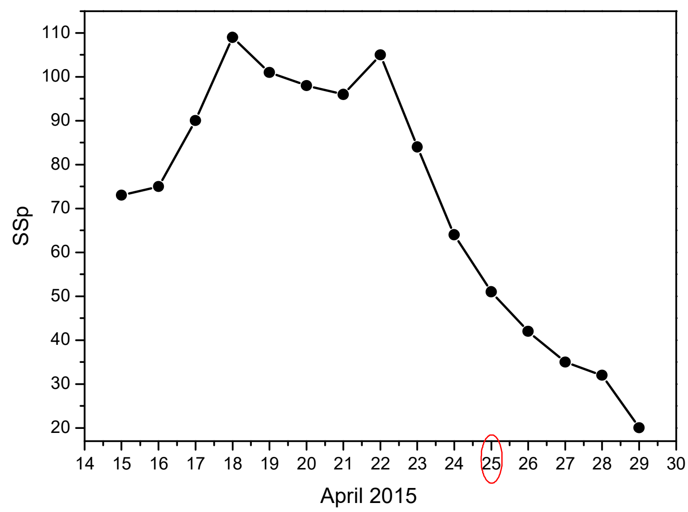


Fig. 27. Kuril, April 19, 2013



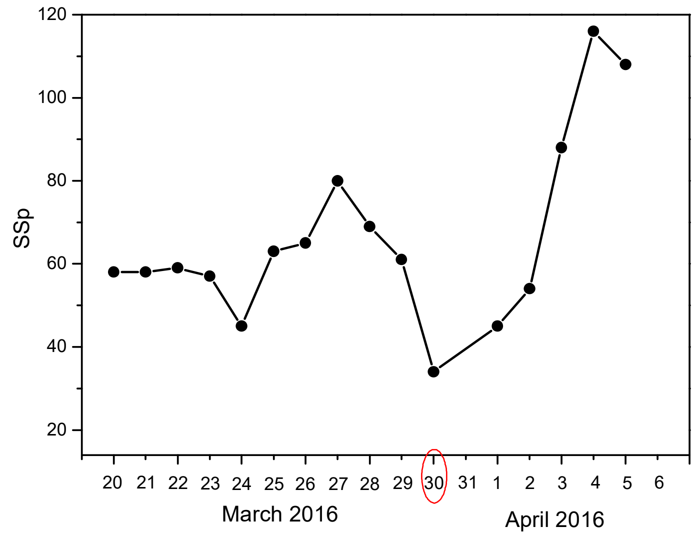


Fig. 15. Nepal, April 25, 2015

Fig. 16. Kamchatka, March 30, 2016

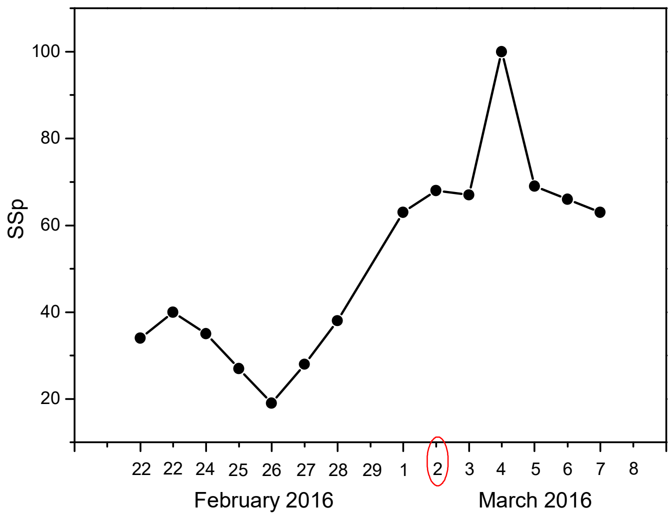


Fig. 30. Sumatra, March 2, 2016

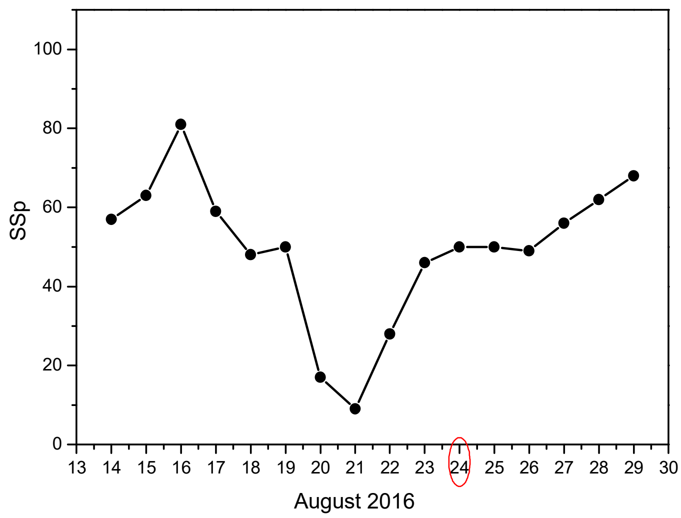


Fig. 31. Italy, August 24, 2016

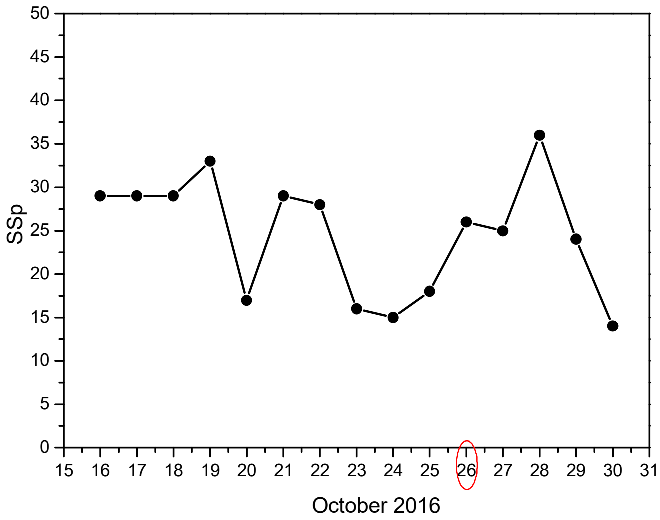


Fig. 32 Italy, October 26, 2016

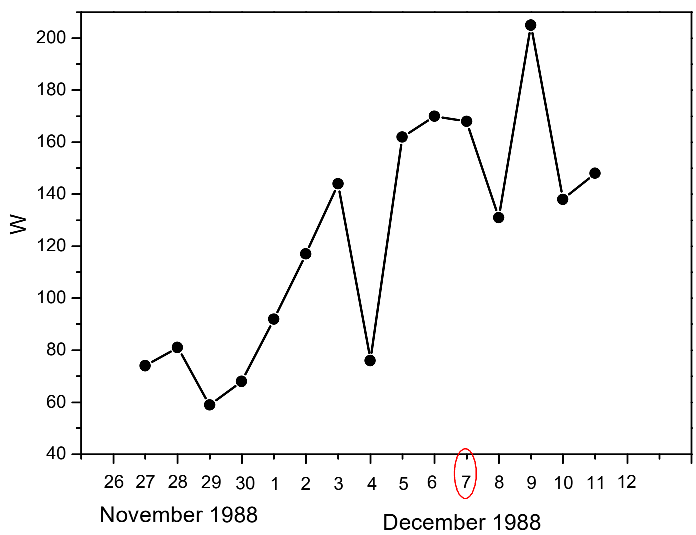


Fig. 33. Armenia, December 7, 1988

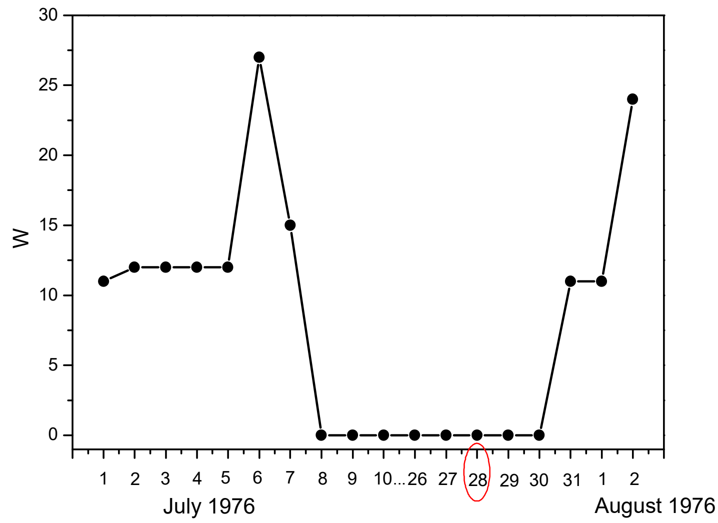


Fig. 34. China, Jule 28, 1976

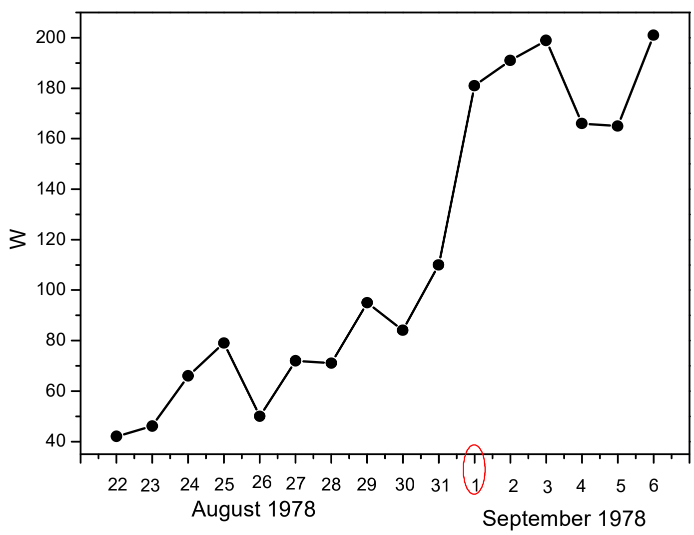


Fig. 35. Iran, September 1, 1978

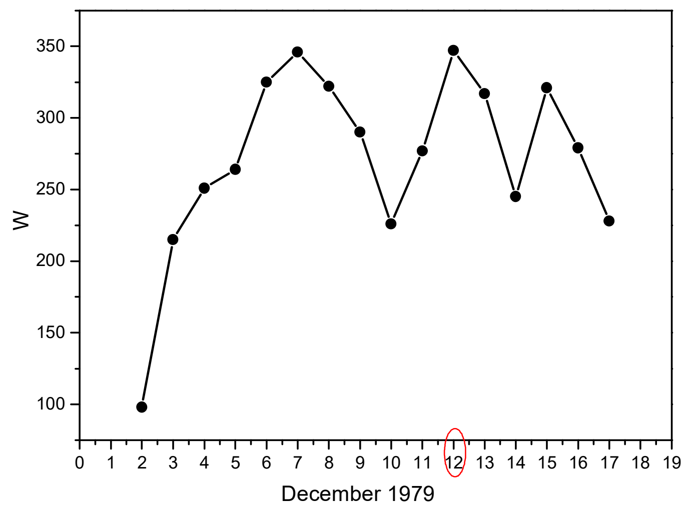


Fig. 36. Ecuador, December 12, 1979

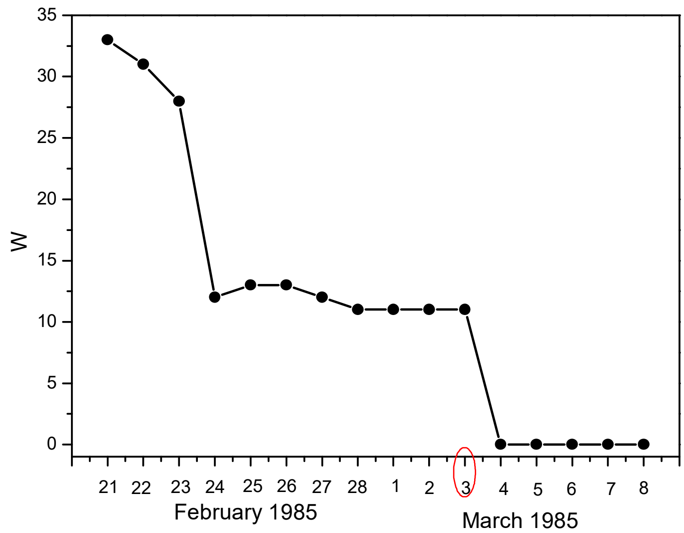


Fig. 37. Chile, March 3, 1985

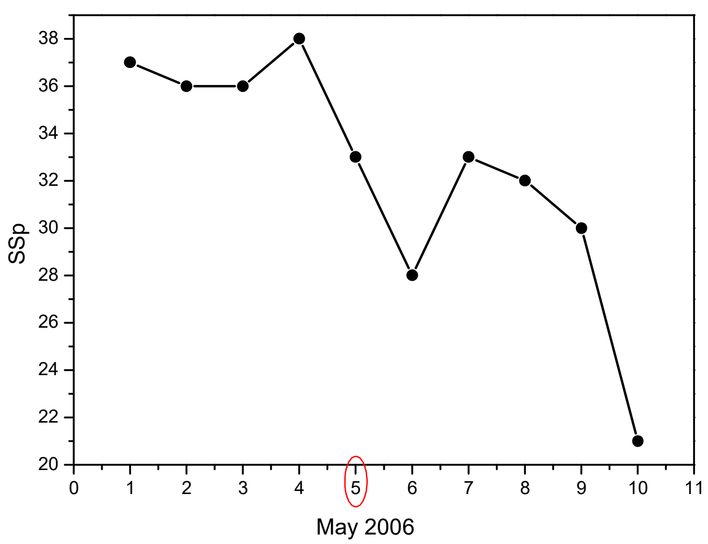


Fig. 38 Tonga, May 5, 2006

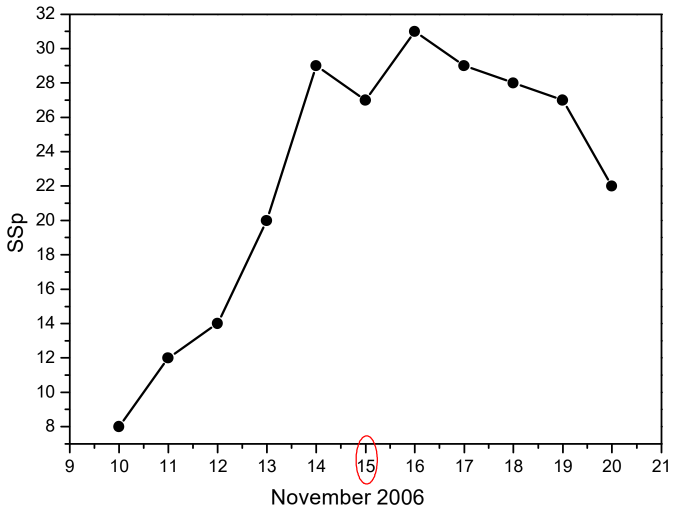


Fig. 39. Kuril, November 15, 2006

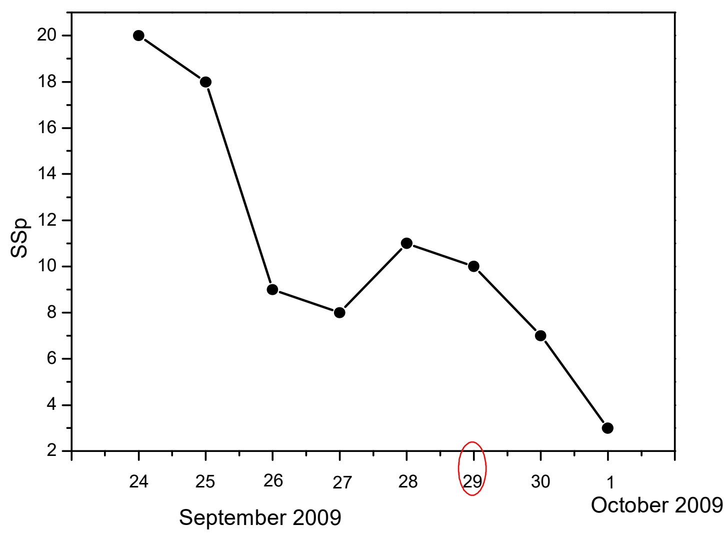


Fig. 40. Samoa, September 29, 2009

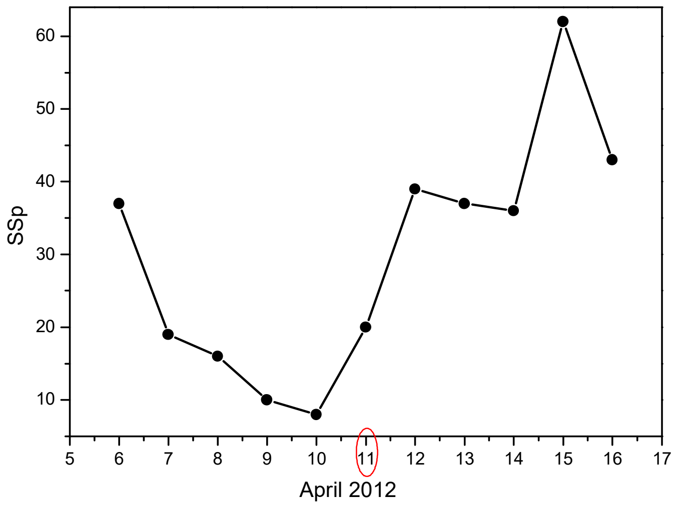


Fig. 41. Sumatra, April 11, 2012

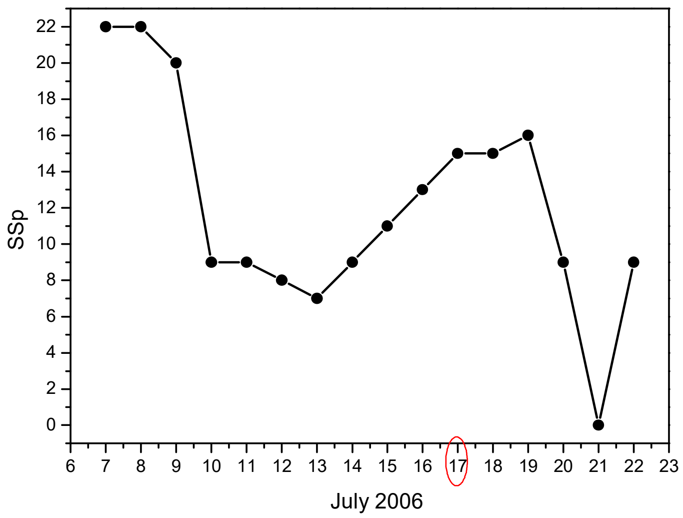


Fig. 42. South of Java, July, 2006

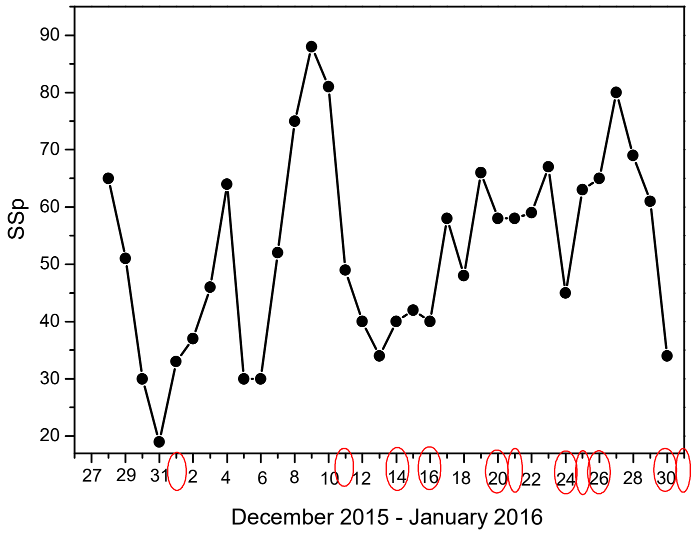


Fig. 43

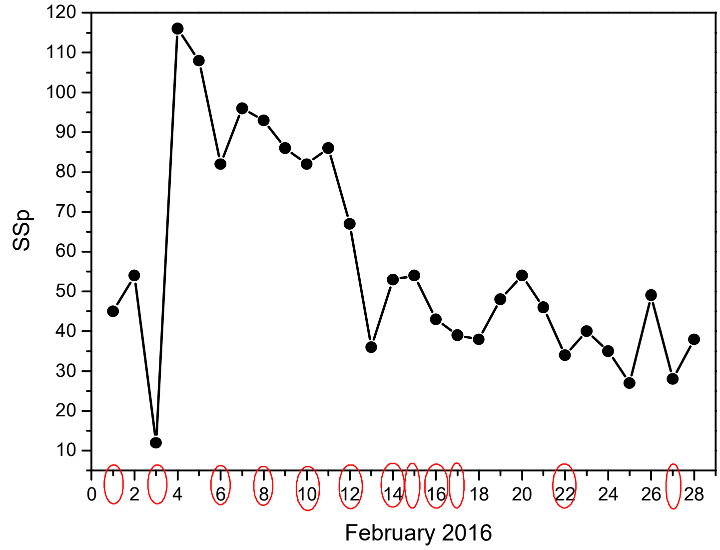


Fig. 44

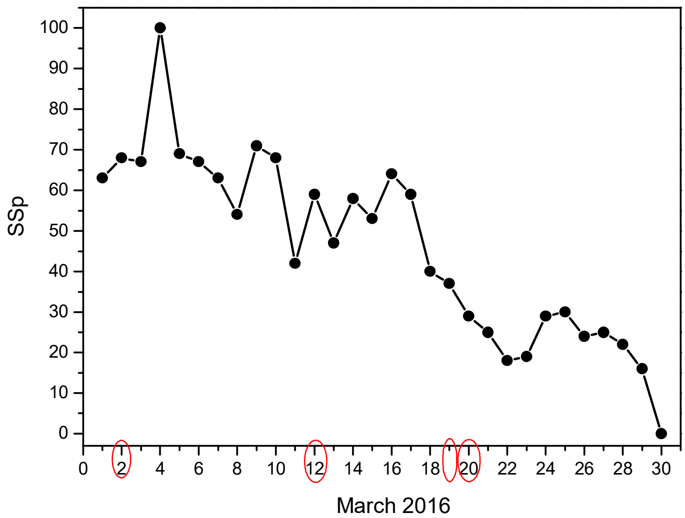


Fig. 45

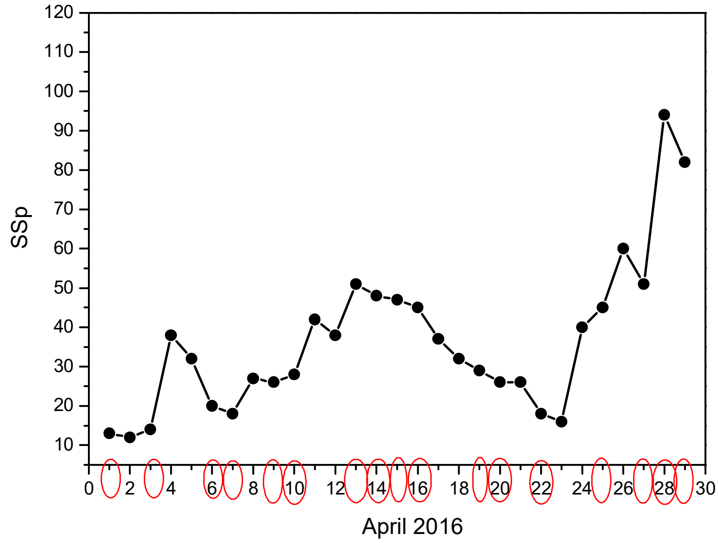
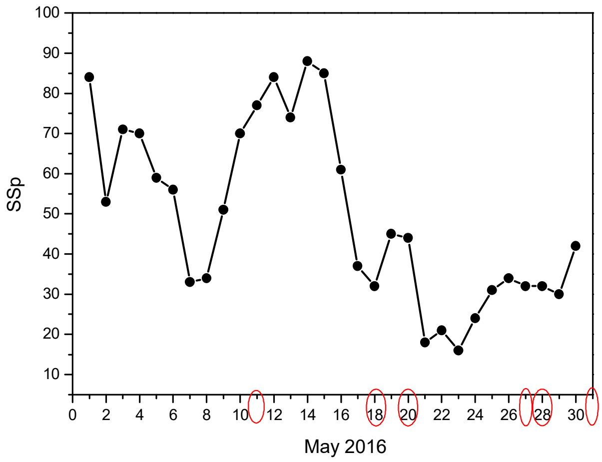


Fig. 46



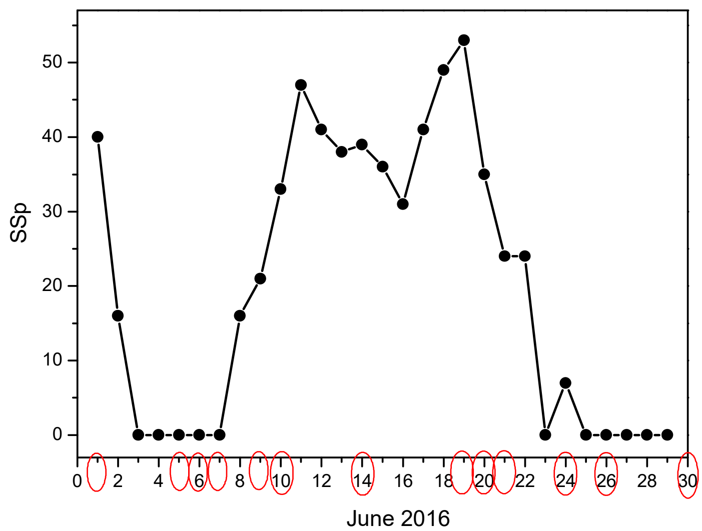


Fig. 47

Fig. 48

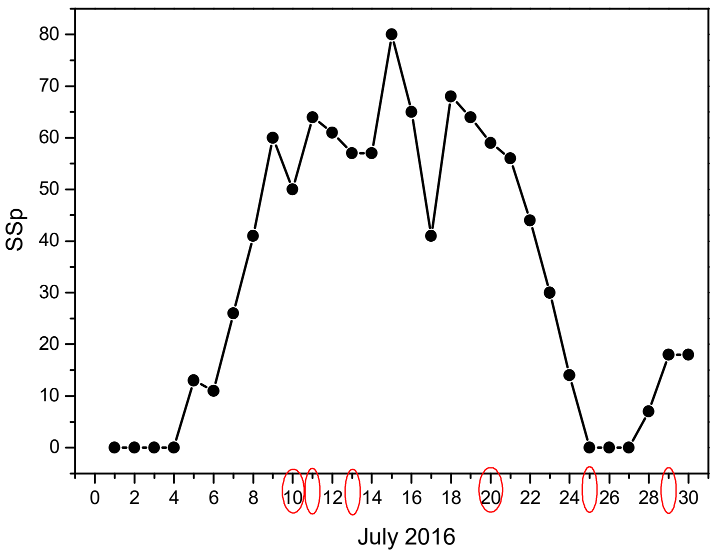


Fig. 49

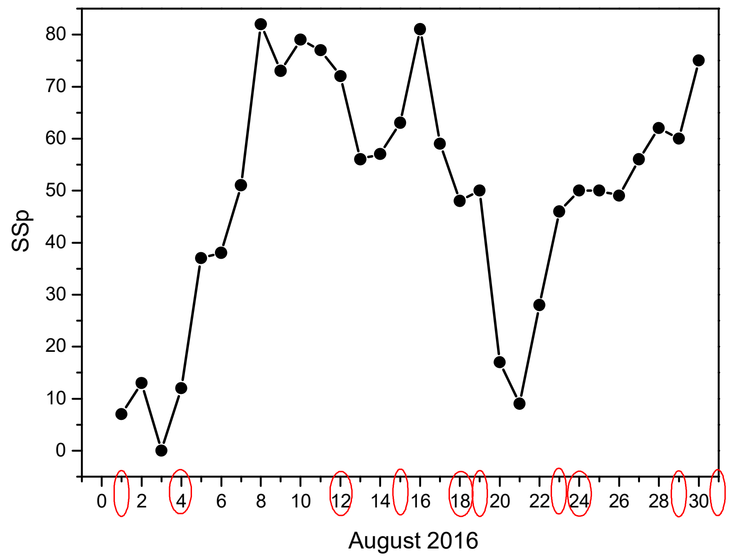


Fig. 50

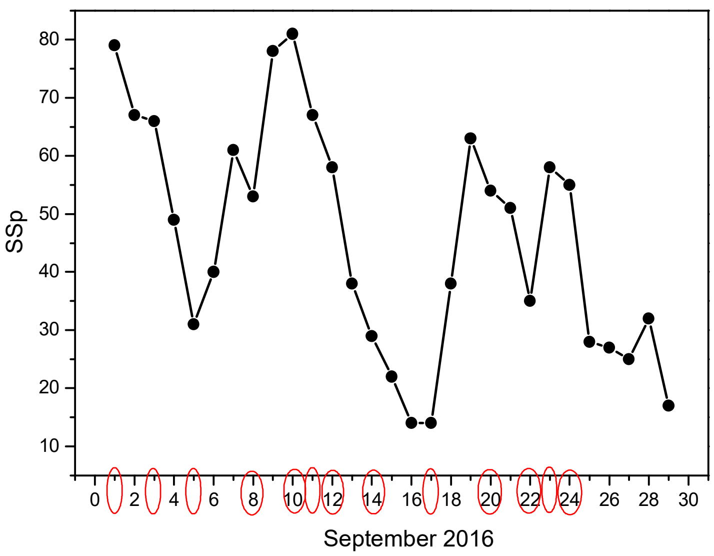


Fig. 51

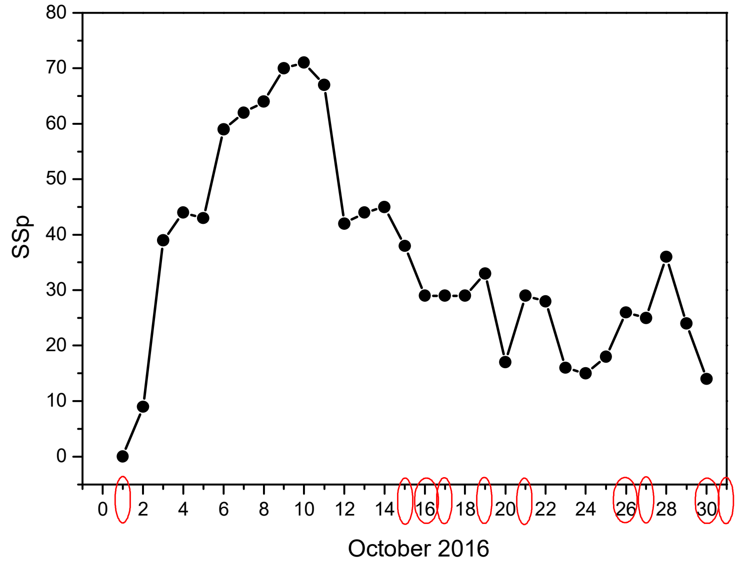


Fig. 52

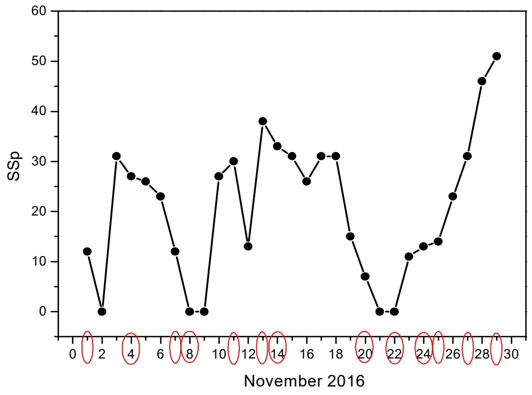


Fig. 53

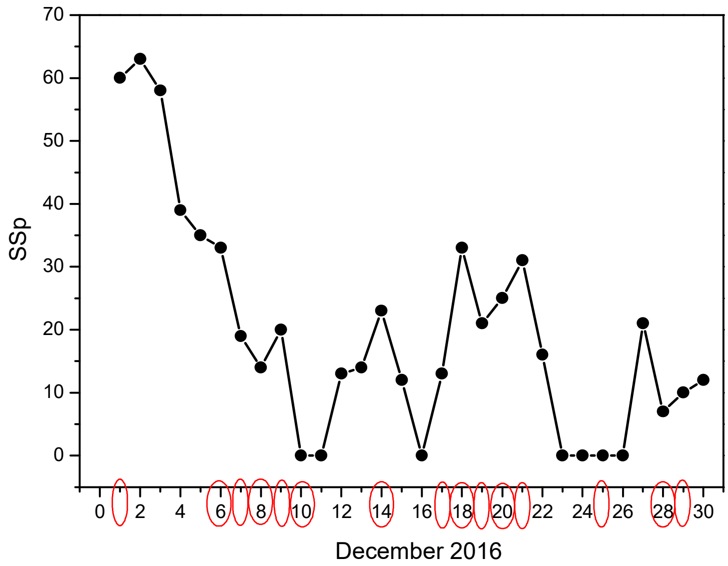


Fig. 54

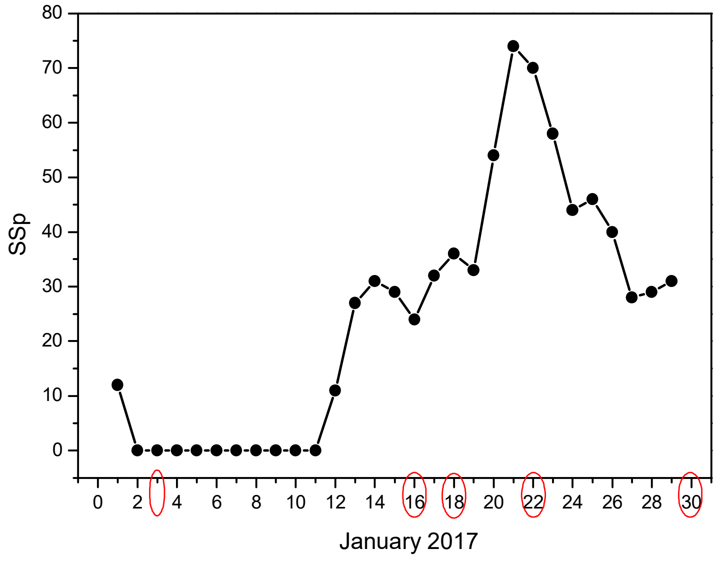


Fig. 55

Кореляція між сонячною і сейсмічною активністю. Про прогнозування землетрусів і вивержень вулканів.

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Великі землетруси і виверження вулканів порівняно з сонячною активністю. Знайдена тісна кореляція між сонячними і земними процесами. А оскільки сонячна активність прогнозована достатньо точно, це дає можливість прогнозувати землетруси і виверження вулканів за декілька днів. Саме це є основним результатом даної статті. В усіх розглянутих випадках наш прогноз вже підтвердився.

Ключові слова: землетруси, виверження вулканів, прогноз.

Корреляция между солнечной и сейсмической активностью.

О прогнозировании землетрясений и извержений вулканов.

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Крупные землетрясения и сильные извержения вулканов сопоставляются с солнечной активностью. Найдена тесная корреляция между солнечными и земными процессами. А поскольку солнечная активность прогнозируема с достаточной точностью, это позволяет прогнозировать землетрясения и извержения вулканов с заблаговременностью в несколько дней. Именно это и является основным результатом данной статьи. Во всех рассматриваемых случаях наш прогноз уже подтвердился.

Ключевые слова: землетрясения, извержения вулканов, прогноз.

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