International Archive of Applied Sciences and Technology, Vol 1 [1] JUNE 2010: 79-83

ISSN 0976- 4828
http:// www.soeagra.com

ORGINAL ARTICLE

Pre and Post Seismic Condition for 2001 Earthquake in Japan

Mahmudul Alam
Disaster Prevention Research Institute, Research Center for Earthquake Prediction, Kyoto University, Obaku, Uji-shi, Kyoto 611-0011, Japan
Email: m.alam@aw2.ecs.kyoto-u.ac.jp or mmalamstat@gmail.com

ABSTRACT
It is a widely accepted idea that most large, shallow earthquakes along island arcs result from active subduction and collection of four lithospheric plates in Japan. Tectonic strain accumulated along the fault zone of the preseismic stage and after accumulating enough strain along the eventual epicentral region then released by the shock. This study found that pre-shock and post shock events continue at least 48 hours in respect to the main shock. That is accumulation of strain energy along the fault zone causes a significant number of earthquakes (pre-shock) and it continues after the main shock (when strain energy is released), at least for a certain period of time. Analytical result shows that two days later after the large earthquake (December 18, 2001), generation of small to moderate earthquakes reduce significantly along that region. That is, after the completion of strain energy, occurrence of earthquakes reduces significantly and the epicentral region is save for at least 50 to 100 years for the next large earthquake.
***KEYWORDS**: Pre-shock, post-shock, seismicity, strain energy, LSD test, Boxplot*

INTRODUCTION

Now a day one of the most popular topics around the world is the devastating characteristics of the worldwide earthquakes, which may occur at any time and at any places without any imaginations like the recent India (2003), Iran (2003), Indonesia (2004), Pakistan (2005), China (2008), Haiti (2010) and Chile (2010) earthquakes.

Among the most prominent goals of seismological research is the prediction of large earthquakes. Several recent successful patterns and studies of precursors to past events suggest that seismicity patterns can play an important role in earthquake prediction programs in future. A wide range of precursory seismicity patterns has been reported prior to the occurrence of large earthquakes, including seismic gaps, quiescence, precursory swarms, foreshocks, earthquake migration, and others (Kanamori, 1981, Habermann, 1988, Wyss and Habermann, 1988, Wu et al., 1991, Mignan et al., 2006, Alam, 2010). A statistical method is used to measure variations in seismicity rates in order to provide a more rigorous means to evaluate changes in space-time seismicity patterns (Zheng et al., 1995). After the prediction of seismicity gaps (Alam, 2007), a possible large earthquake location is identified in Ryukyu Islands, Japan and a large earthquakes occurred at the same location in 2009. Kimura (1976) suggest that the occurrence of large earthquake sometimes depends on major eruption. Though major eruptions and large earthquakes has time-distance relation (Alam and Kimura, 2004) but this earthquake (December 18, 2001 with magnitude M = 7.2) may not have any relation to major eruptions.

An attempt is made to find out the relationship between magnitude, intensity, and other focal parameters relating to earthquake. Pre and post seismic condition around the epicentral region after the occurrence of a large earthquake is also observed.

MATERIALS AND METHODS

A number of earthquakes with magnitude greater 7.0 occurred in Japan during the 19th and 20th century. The year 2001 is selected using PPS sampling (Probability proportion to sample) depending on the magnitude greater than 7.0 since 1950. According to JMA (Japan Meteorological Agency) more than 15053 earthquakes occurred during 2001 with magnitude $M \geq 2.0$ and depth ≤ 100 kilometers in Japan (Table 1). LSD (least significance difference) and Duncan Multiple range test is applied to show the seasonal variations. Boxplots is a technique for detecting outliers and presentation of data for which anyone may understand the characteristics of the observation. Usually, Boxplots show the median, interquartile range, outliers, and extreme cases of individual variables. The box represents the interquartile range which contains the 50% values. The whiskers are lines that extend from the box to the highest and lowest values, excluding outliers. A line across the box indicates the median. To detect the outliers we may use the approximations as: the observations which lie out sides of the limit $\pm 3\sigma$ or $\pm 2.5\sigma$ are outliers (σ is known as standard deviation). Regression and correlation coefficients are test to show the significant relation among the focal parameters.

RESULTS AND DISCUSSION

Earthquake is one kind of catastrophe failure. It is very difficult to find out which mechanisms are related to such kind of failure. Although Alam *et al*., (2004) has shown in their studies that volcanic activities and occurrence of large earthquakes (M>7.1) are closely related to the change of stress activity. But for the earthquakes in 2001 they did not find any major eruptions that may cause the occurrence the earthquake (Alam and Kimura, 2004). They also suggest that major eruptions and large earthquakes have time distance relationship but there are so many large earthquakes striking in the world recently, have no relation with major eruptions.

Table 1. Earthquake distribution based on magnitude and month

Magnitude	***Month***												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
2.00	251	177	160	160	146	128	108	145	117	158	134	177	1861
2.10	257	130	163	140	146	136	153	115	121	130	109	144	1744
2.20	185	148	134	106	143	117	140	105	105	118	83	139	1523
2.30	168	139	129	82	102	116	121	95	89	99	92	119	1351
2.40	127	118	94	67	103	87	65	89	72	80	89	111	1102
2.50	126	97	77	84	72	86	70	81	70	73	81	87	1004
2.60	110	74	77	80	64	70	68	79	68	78	78	75	921
2.70	80	61	71	52	64	55	65	52	64	77	79	85	805
2.80	88	59	69	55	59	49	58	58	42	59	54	63	713
2.90	54	49	55	46	45	67	73	45	57	59	43	72	665
3.00	47	39	41	41	47	41	45	28	35	38	33	51	486
3.10	41	33	38	26	47	41	43	31	29	40	34	47	450
3.20	39	33	35	25	37	33	41	21	20	43	26	31	384
3.30	35	32	41	34	29	31	34	24	19	31	25	26	361
3.40	28	25	25	18	23	30	29	14	15	24	17	27	275
3.50	19	15	26	14	24	23	23	22	16	14	13	20	229
3.60	17	11	14	13	19	16	25	15	20	11	10	16	187
3.70	10	7	11	8	17	16	14	9	9	11	9	15	136
3.80	16	15	6	12	9	11	19	6	9	3	16	14	136
3.90	14	10	5	11	5	5	15	6	8	11	7	11	108
4.00	8	4	14	7	11	9	10	7	4	10	11	8	103
4.10	13	4	9	8	13	6	4	5	10	7	2	9	90
4.20	6	4	11	8	8	3	8	5	5	2	7	5	72
4.30	4	4	2	2	9	6	7	3	8	7	2	6	60
4.40	3	3	7	5	9	4	3	2	4	2	2	4	48
4.50	6	8	3	4	4	6	8	1	1	6	7	2	56
4.60	5	2	2	5	6	5	6	4	2	2	2	5	46
4.70	3	1	1	1	5	4	4	1	1	2	3	3	29
4.80	2	1	1	1	1	1	4		1	1	1		14
4.90				1	1	2			2	3	1	1	11
5.00		1		1	3	1	5	2		2	3	2	20
5.10	1		1	1	2	1	3			1	1	2	13
5.20	1		2		2	1	1		1	1			9
5.30	1		2	1	1			2	2	2	1		12
5.40				1	1		1	1					4
5.50		1					1			1			3
5.60	2			2	1								5
5.80				1			1						2
5.90		1		1			2		1				5
6.00		1	1			1						1	4
6.10												1	1
6.40								1					1
6.60				1									1
6.70			1										1
6.90					1								1
7.20												1	1
Total	1767	1307	1328	1125	1279	1208	1277	1074	1027	1206	1075	1380	15053

From the cross tabulation and Boxplot we observe that most of the earthquakes occurred in 2001 are instrumental to very strong with magnitudes 2 to 6.1, and a very few with magnitude 6.2 to 7.2 (Fig.1). The figure also shows that the earthquake of magnitude 7.2 is an outlier.

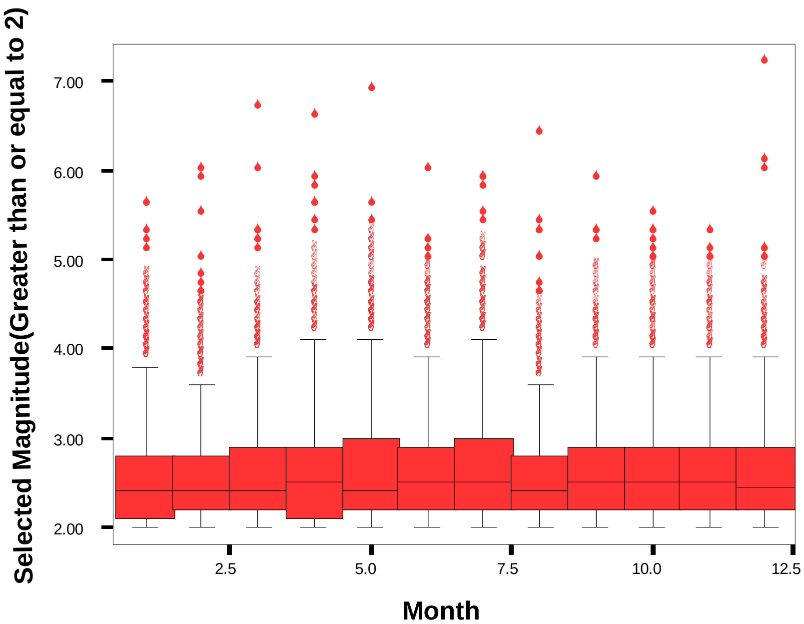

Fig.1 Seismic distribution and detection of outlier

LSD and Duncan Multiple range test suggest that there exist no significant variations among the seasons (spring, summer, rainy and winter). To examine the seasonal variations, the earthquakes since 1950 are classified into four seasons but both tests are unable to find out any significant variations (results are not shown in the text).

The regression analysis and correlation coefficient (r = 0.54) test suggest that magnitude and maximum intensity are significantly related but there exist no relation with the epicentral depth (Table 2).

Table 2. Analysis of variance (ANOVA) and single coefficient test

ANOVA					
	Sum of Squares	Df	Mean Square	F	Sig.
Regression	188.938	1	188.938	479.358	.000
Residual	500.173	1269	.394		
Total	689.111	1270			
Coefficient test					
	Coefficients	Std. Error	Standardized Coefficients	Test statistic (t)	
(Constant)	1.649E-02	.069		.239	.811
Magnitude	.455	.021	.524	21.894	.000

Though our analytical result suggests that there is no significant relation between intensity and epicentral depth but for careful examination of some great earthquakes we have seen that for shallow level earthquakes (with same magnitude), maximum intensity is higher than the deep level earthquake

(Alam, 2009). Damage depends on the intensity together with the structural condition of the epicentral region.

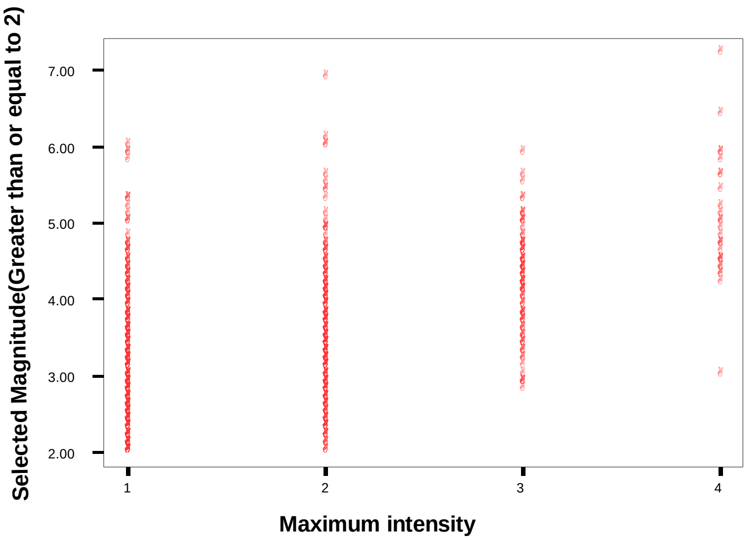

Fig. 2. Relation between magnitude and seismic intensity

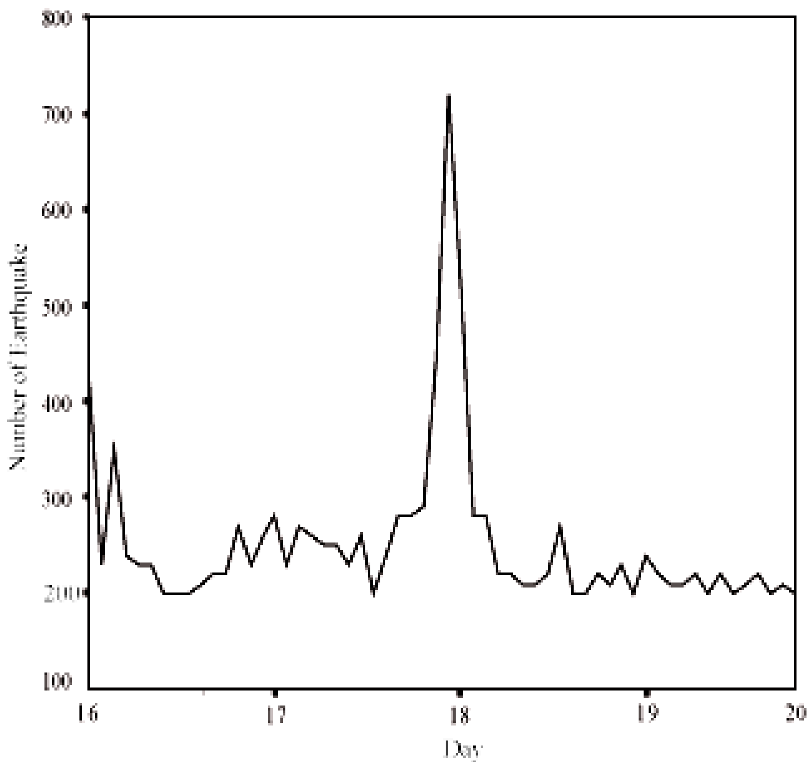

Fig. 3. Earthquake distribution before and after the occurrence of the great earthquake in 2001.

Regional strain accumulated near the eventual epicentral region prior to the occurrence of a large earthquake and when enough strain accumulated then is released by the shock. We have shown the pre seismic and post seismic condition before the occurrence of large earthquakes in December 18, 2001 (Fig. 3).

Due to the accumulation of strain energy, a lot of micro and semi-macro earthquakes occurred along the epicentral region to warn us about the devastating one from December 16 and after the occurrence of the earthquake (December 18, 2001), a large no. of occurrence also happened until December 20 due to the strain release. But we could not comment that all the large occurrence follow the same time interval since we did not examine other large earthquakes except the 2001.

Conclusion

The size of the earthquake plays an important role for disaster in both properties and life. Disaster also depends on the hypocenteral depth of the earthquake. Shallow level earthquakes damaged more than the others. In 2001, a great earthquake (M=7.2) occurred along the surface (depth = 0.08 km) in Japan. A lot of earthquakes with small to moderate size also occurred within a very short interval of time and a short distance along the epicentral region. According to the analysis it may conclude that a lot of small to moderate size foreshock and aftershock events occurred along the epicentral region. Foreshocks may be a precursor for accessing the main shock. If it is possible to locate the fault region or strain migration region concerning the foreshocks region, the main shock may be identified. However, sometimes aftershock may exceed main shock in size and destruction may exceed the limit of main shock. To clarify the main shock and aftershock events, aftershock decay rate assessment is needed for assessing the aftershock events.

REFERENCES

[1] Alam, M.M. (2010). Time series modeling for forecasting the earthquake behavior of Indonesia**.** Presented on the 4th IASME/WSEAS International Conference on GEOLOGY and SEISMOLOGY (GES '10) on Feb. 23-25, 2010, Cambridge, Uk.

[2] Alam, M.M. (2009). Effect of Magnitude on time-space relationship model. *Geophysical Journal*, 31(**2**): 141-146.

[3] Alam, M.M. (2007). Location identification of future large earthquakes in Ryukyu Islands. J. Sci. (Part-B) 31: 35-41.

[4] Alam, M.M., and Kimura, M. (2004). Statistical analysis of time-distance relationship between volcanic eruptions and great earthquakes in Japan. Earth Planets Space, 56: 179-192.

[5] Alam, M.M., Ali, M.A. and Kimura, M. (2004). Time-Distance relationship between volcanic eruptions and large earthquakes in central Japan: A Statistical Analysis. International Journal of Statistical Sciences, 3: 53-66.

[6] Haberman, R.E. (1988). Precursory seismic quiescence; past, present and future. Pure Appl. Geophys. 126: 277-318.

[7] Kanamori, H. (1981). The nature of seismicity patterns before large earthquakes, in Earthquake Prediction: An International Review. Geophys. Monogr.Ser., 1–19, AGU, Washington, D. C.

[8] Kimura, M., (1976). Major magmatic activity as a key to predicting large earthquakes along Sagami Trough, Japan. *Nature*, 260: 131-133.

[9] Mignan A., King G., Bowman D., Lacassin R., Dmowska R., (2006). Seismic activity in the Sumatra-Java region prior to the December 26, 2004 (M_w = 9.0-9.3) and March 2005 (M_w=8.7) earthquakes. Earth and Planetary Science Letters, 244: 639-654.

[10] Wu, K.T., Yue M.S., Wu H.Y., Chao S.L., Chen H.T., Huang W.Q., Tien K.Y., Lu S.D. (1991). Foreshocks to Haicheng earthquake of 1975, in Evaluation of Proposed Earthquake Precursors, M. Wyss (Editors), American Geophysical Union, Washington, D.C., 12-14.

[11] Wyss, M. and Habermann, R. E. (1988). Precursory seismic quiescence. Pure Appl. Geophys. 126: 319–332, 1988.

[12] Zheng B, Hamburger M.W., Popandopulo G.A., (1995). Precursory seismicity changes preceding moderate and large earthquakes in the garm region, central Asia. Bull. Seism. Soc. Am. 85(2): 571-589.