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Time:May 27 14:15-16:15

Proximity of the lunar days for the devastating earthquakes in the off-Sanriku region: the effects of earth tides

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It is known that earth tides, which are the effects of gravitational pulls by the moon and the sun, have an influence on earthquake occurrences. For details, there is an apparent increase in occurrence of earthquakes, when earth tides so work on faults or plate boundaries that change of stress on them assists fracturing (e.g., Tanaka et al., 2004). Regarding the moon, the sun and the earth on such an occasion, on the other hand, a specific positional relationship producing the change exists. This positional relationship can be identified by "the ecliptic longitude difference between the moon and the sun (ELDMS, 0-360 degrees)". It can also be determined by the day of the lunar calendar (1-29 or 30th), or days from/to such specific positions of the moon as New, First quarter, Full and Last quarter moon. They are accessible indexes, although the amount of error may increase.

The off-Sanriku region is the region where large earthquakes often occur. Even in the recent times, the 1896 Meiji Sanriku EQ(M8.5) and the 1933 Showa Sanriku EQ(M8.1) occurred. For this region and neighboring the off-Miyagi Pref. region, special occurrence patterns depending on earth tides are reported (Sue, 2007 and Sue, 2008). At 14:46 on March 11, 2011 (JST), an earthquake of M9.0 occurred and created huge damages in this region, therefore such tendency is investigated. An earthquake of M7.3 occurred near the focal region two days before the main shock and the earthquake is also investigated, because the earthquake can be a foreshock. A large aftershock of M7.4 occurred again on April 7, almost one month later. And this earthquake is also added to the investigation.

Date	Name	M	ELDMS	L. cal.	Casualties
			(deg.)	(day)	(abt.)
1896/6/15	Meiji Sanriku	8.5	50	5th	22,000
1933/3/3	Showa Sanriku	8.1	71	8th	3,000
2011/3/9	Off-Sanriku	7.3	46	5th	-
2011/3/11	Main shock	9.0	70	7th	26,000
2011/4/7	Off-Miyagi P.	7.4	44	5th	-

(Main shock: 2011 Japan's tohoku earthquake)

It is known that the earthquakes of March 9 and 11 occurred under close lunar conditions with those of the 1896EQ(M8.5) and the 1933EQ(M8.1) respectively. In addition, the earthquake of April 7 occurred also under close lunar conditions as those for the 1896EQ(M8.5) and the March 9 EQ. Therefore remarkable concentration of occurrences for the ELDMS of 40-70 degrees is observed. This is consistent with the report that there is concentration of occurrence to the ELDMS of 20-80 degrees for the earthquake in this region (Sue, 2008). As for the month of occurrence, by taking other earthquakes in this region into account, from March to July seem to have much occurrence of large earthquakes. This can be regarded as solar contribution to the earth tides, while it needs future examination.

As reported here, the large earthquakes occurred under influence of the earth tides in specific ways to the region, and this means that earthquakes occur at the similar ELDMS, or on the same days of the lunar calendar. This further implies that earthquakes have been occurring on the same lunar days in each region from the past. Furthermore, there may be certain tendency on months of occurrence. These understandings may be similar to "The nature" is faithful to old customs." by the renowned physicist Torahiko Terada (Tsunami and humankind, 1933). The understanding on these phenomena should help prevention or mitigation of disasters.

References

Y. Sue, The phase of the moon at the earthquakes occurred in the central off-Sanriku region, JPGU S145-P004, 2008 (in Japanese).

Y. Sue, SSJ P2-056, 2007 (in Japanese).

S. Tanaka, M. Ohtake, and H. Sato, Tidal triggering of earthquakes in Japan related to the regional tectonic stress, *Earth Planets Space*, Vol.56, No.5, pp.511-515, 2004.

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