Comments on Earthquake Statistics

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April 27, 2010 (10:00 A.M. EDT, 14:00 UTC/GMT)
Updated May 5, 2010
Link: http://web.ics.purdue.edu/~braile/new/EqStatistics.pdf

I am a seismologist and can't resist commenting on yesterday's event that considered earthquake occurrences and "immodestly dressed women." The event was inspired by Purdue student Jennifer McCreight to test whether women's dress could cause earthquakes as had been suggested by an Iranian cleric (http://www.blaghag.com/2010/04/and-boobquake-results-are-in.html). Of course, as a one-time, one-day experiment, the test is not extensive and cannot be used to scientifically and quantitatively produce a conclusion. Ms. McCreight clearly recognizes these limitations in her discussion. Additional questions on appropriate procedures to test the hypothesis include: Over what magnitude range should the earthquakes be counted? Over what time period should the earthquakes be counted? Should the maximum magnitude for each day be considered? What geographic area should be considered? My intention in these comments is to add some background on the statistics of earthquakes to the discussion of this interesting experiment, and, hopefully, increase public understanding and awareness of earthquakes.

Although seismologists understand the basic causes and processes of earthquakes, many questions remain and it is generally agreed that there is, at this time, no reliable method to predict earthquakes. The term prediction is meant to include a reasonably accurate estimate of the time, location and magnitude of a future earthquake, as well as a scientific basis for the prediction method such that the method can be tested and utilized for additional events. I know of no evidence that correlates human dress or individual behavior with earthquakes. However, some human activities do cause earthquakes. These activities include very large explosions, fluid injection or pumping in deep wells, and surface loading such as the filling of a large reservoir after a dam is constructed. The triggered earthquakes, from these activities are small compared to the major earthquakes that sometimes occur on the Earth's plate boundaries and major faults that are associated with the geological process known as plate tectonics (http://earthquake.usgs.gov/learn/topics/plate_tectonics/rift_man.php, http://pubs.usgs.gov/gip/dynamic/dynamic.html). Triggered events (from human activities) also occur near the location of the triggering activity.

Past earthquake occurrences and earthquake statistics do provide data for forecasting the probability of future events in both space and time. Earthquakes occur every day. In fact, it is estimated that over 1.5 million earthquakes of magnitude 2 or greater (often referred to as M2+

earthquakes) occur every year somewhere on Earth – that's over 4000 earthquakes per day! For magnitude 3 and larger – events that can sometimes be felt by people if the earthquake occurs in a populated area – the number of occurrences is estimated to be over 400 per day. Information on the frequency of earthquakes and the relative shaking and energy release for different magnitudes is provided in the two tables below from the U.S. Geological Survey web page (http://earthquake.usgs.gov/earthquakes/eqarchives/year/eqstats.php).

Frequency of Occurrence of Earthquakes

Magnitude	Average Annually
8 and higher	1[1]
7 - 7.9	15 [1]
6 - 6.9	134 [2]
5 - 5.9	1319 [2]
4 - 4.9	13,000 (estimated)
3 - 3.9	130,000 (estimated)
2 - 2.9	1,300,000 (estimated)

[1] Based on observations since 1900.
These numbers have been recently updated, based on data from the Centennial catalog (from 1900 to 1999) and the PDE (since 2000).
[2] Based on observations since 1990.
(http://earthquake.usgs.gov/earthquakes/eqarchives/year/eqstats.php)

Magnitude vs. Ground Motion and Energy

Magnitude Change	Ground Motion Change (Displacement)	Energy Change
1.0	10.0 times	about 32 times
0.5	3.2 times	about 5.5 times
0.3	2.0 times	about 3 times
0.1	1.3 times	about 1.4 times

This table shows that a magnitude 7.2 earthquake produces 10 times more ground motion than a magnitude 6.2 earthquake, but it releases about 32 times more energy. The energy release best indicates the destructive power of an earthquake. See: How much bigger is a magnitude 8.7 earthquake than a magnitude 5.8 earthquake?
(http://earthquake.usgs.gov/earthquakes/eqarchives/year/eqstats.php)

Because the number of earthquakes over any given time period is related to the magnitude of events considered (as shown in the Frequency of Occurrence of Earthquakes table above), statistical study of earthquakes must include consideration of magnitudes of events not just the number of earthquakes in a time interval. For larger earthquakes, M5 and greater, a summary of average worldwide occurrence is given in the table below. As an example, there are about 4 M5+ earthquakes per day (on the average). One can easily monitor these events at the USGS web page http://earthquake.usgs.gov/earthquakes/recenteqsww/Quakes/quakes_big.php, and find

additional information on earthquakes and earthquake activity at http://earthquake.usgs.gov/. A useful and attractive world map of current earthquake activity is also available at http://www.iris.edu/seismon/.

Worldwide Earthquake Occurrence of Magnitude 5, 6 and 7 and Greater*

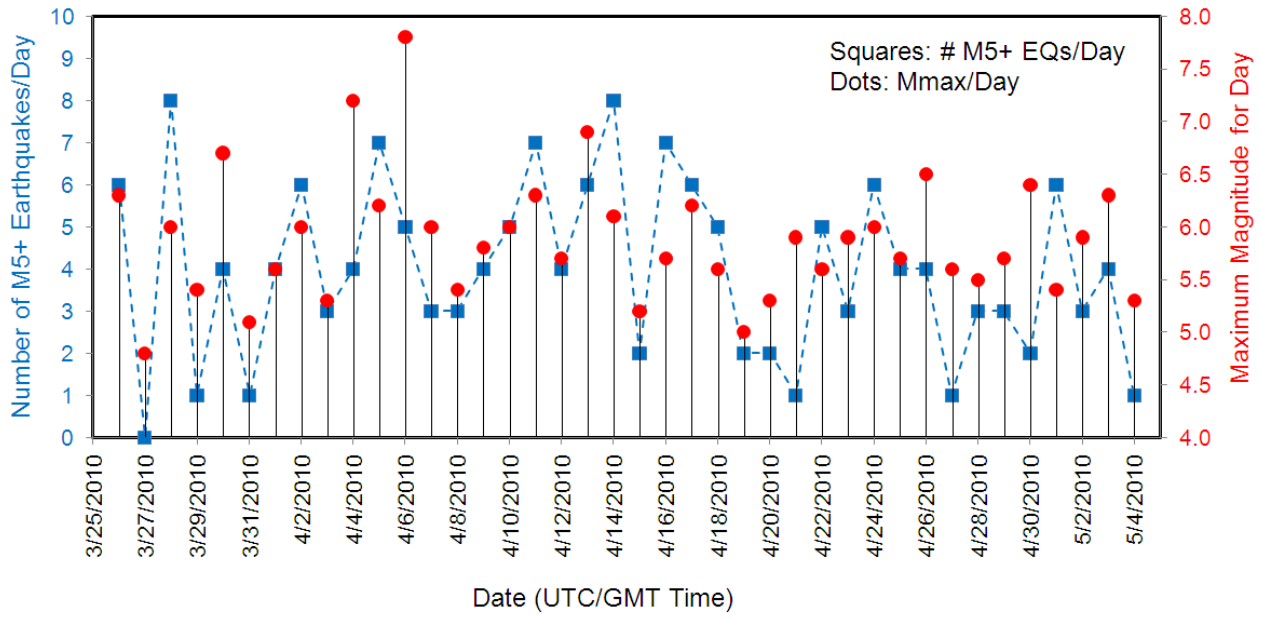
Magnitude Range	Worldwide Number per Year	Average Worldwide Number per Day	Average Rate of Occurrence
7 and higher	16	0.0438	1 every 22.8 days
6 and higher	150	0.411	1 every 2.44 days
5 and higher	1469	4.02	1 every 6 hours

* From data in USGS Frequency of Occurrence of Earthquakes table, above.

There is considerable variation in the number of earthquakes over time for earthquakes of any magnitude range. For example, for M7+ worldwide earthquakes per year since 1900, the number per year averages 16, but the minimum number per year was 6 (in 1986 and 1989) and the maximum number per year was 32 (in 1943). The standard deviation of the number of M7+ earthquakes per year since 1900 is 4.818 years.

Worldwide earthquake activity (M5+) for approximately the past month is shown in the graph below. Time of day is referenced to Coordinated Universal Time (UTC), also referred to as Greenwich Mean Time (GMT) and is four hours ahead of Eastern Daylight Time (EDT). The number of earthquakes of M5 or greater on April 26, 2010 was 4, consistent with the long term average discussed above. In the past month, there were three significant large earthquakes – the M7.2 Baja earthquake of April 4, the M7.8 Northern Sumatra earthquake of April 6, and the M6.9 Southern Qinghai, China earthquake of April 13. From the average rate of occurrence of M7+ earthquakes (about one every 16 days), intuitively one wouldn't expect three events of this size to occur in less than two weeks. However, "clustering" of large earthquakes is quite common in the historical record of earthquake activity and is consistent with most earthquakes occurring randomly in time. The M6.5 earthquake (Southeast of Taiwan) on April 26 was a significant event, but one can see from the graph that its magnitude is not markedly unusual as compared to the maximum daily magnitudes of the past month, and, from April 18 to 25 (eight days), the largest magnitude earthquake was M6.0 on April 24, compared with the average rate of M6+ earthquakes which is one every 2.44 days. Currently (14:00 UTC, April 27, 2010), there have been no M5+ earthquakes on April 27 the day after McCreighty's experiment.

May 5, 2010 update: Worldwide earthquake data have now been updated through May 4, 2010.



Worldwide earthquake activity during late March, April and early May, 2010, for earthquakes of magnitude 5 or greater.

I will periodically update this graph online for the next several weeks to provide additional activity to compare with April 26.