Earthquake Analysis 2010

A comparison of the total of earthquakes for 2010 to the preceding years 2000 – 2009. (Rev Oct 2011)

The general impression that abounds is that 2010 was a particularly bad year for earthquakes and that the global incidence of earthquakes is on the increase. But is this indeed so? I take a look at the figures for 2010 and compare them to earlier years on the basis of numbers (which I do not personally consider a viable method of comparison) and on the basis of energy released which I consider to be a more realistic method.

A description of the data sources I used and the spreadsheets into which the data was loaded can be found at the end of the document together with links detailing the source web sites and to a download of the spreadsheet files.

The final two years comprise data that I have collected using the QVS Data program. Since this data is a mixture of USGS, EMSC and GeoNet (New Zealand) data, all non USGS data was removed leaving only that data which has been supplied by the USGS in the 7 day files available on the Internet. These files are downloaded into the program at 5 minute intervals during the day and thus catch any revisions and/or deletions provided they happen within a 7 day time span. For the most part I consider this to be the case.

To get a figure for energy it was assumed that all earthquakes were of the same scale (which some may not be) since any differences would be minor and should tend to cancel out. The formula used is:

$$Es = (10^{(4.8+(G2*1.5))})/(10^{12})$$

This gives an energy value in Terajoules and since a magnitude 5 earthquake is 2 TJ of energy this scale has been used throughout. See Wikipedia for information on Joules.

Magnitude	Es (from Me)	Es (from Ms or Mw)	Tons of TNT	Nuclear Bomb Equivalence (# of bombs)
4	2.20E+10	6.30E+10	15	0
5	7.10E+11	2.00E+12	475	0.02
6	2.20E+13	6.30E+13	15023	0.79
7	7.10E+14	2.00E+15	475063	25
8	2.20E+16	6.30E+16	15022833	790.6
9	7.10E+17	2.00E+18	475063712	25,003.30

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The table above and the information on the calculation was taken from the USGS page on FAQs – Measuring Earthquakes.

> *The radiated energy can be obtained in various ways. Historically, the radiated energy was estimated empirically (from observations) from magnitude Ms through the Richter formula, log Es = 4.8 + 1.5Ms, where Es is seismic energy in Joules. In this formula, magnitude is measured first, after which the formula is used to obtain Es.*

The data is collected into a front sheet in each spreadsheet, and then to a collection in the main spreadsheet. At this point the aggregated values have been converted to Petajoules.

Without further ado the basic figures look like this. First the raw count of earthquakes:

Raw Counts													
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2009r	2010r
5.0 - 5.99	1328	1222	1172	1241	1527	1716	1728	2095	1796	1370	1816	1920	1997
6.0 -6.99	140	115	125	141	140	139	142	178	168	134	143	144	151
7.0 -7.99	14	14	13	14	14	10	9	14	12	15	21	16	21
8.0 - 8.99	1	1	0	1	1	1	2	4	0	1	1	1	1
9.0+	0	0	0	0	1	0	0	0	0	0	0	0	0
Total Count	1483	1352	1310	1397	1683	1866	1881	2291	1976	1520	1981	2081	2170

(See the Q2000_2010 spreadsheet for original version)

As you can see from the table 2010 beats all years in the decade 2000 to 2009 with the exception of 2007 which was more active for counts but lower for energy. 2008, only just pipped at the post in terms of count, was actually the lowest for energy of all 11 years.

2008 was not considered to be a particularly active year despite the high count. There was not even a magnitude 8 during the year. In fact there were fewer magnitude 7 earthquakes than average as well so it really was a quiet year. This is one of the reasons why I personally take little notice of the counts and prefer to use the energy released.

2004 of course had the magnitude 9 that gave rise to the Indonesian tsunami with such destructive results and great loss of life. But without that one single event 2004 was very quiet. If that single earthquake is removed from the figures it makes a drastic difference to the energy release and makes 2004 the quietest of all the years except 2008.

The next table is the released energy by magnitude band.

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Energy Released Petajoules (PJ)													
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2009r	2010r
Mag 5	12.3	10.3	10.0	10.6	13.5	13.4	12.7	14.9	12.7	10.6	12.5	12.8	14.0
Mag 6	31.7	28.5	24.5	36.9	32.1	34.3	31.7	44.0	42.8	32.5	38.5	33.4	40.8
Mag 7	208.7	138.7	169.1	119.6	59.6	94.1	80.8	169.0	111.0	166.6	142.9	196.8	157.1
Mag 8	63.1	251.2	0.0	177.8	89.1	501.2	240.9	596.2	0.0	63.1	1000.0	89.1	1000.0
Mag 9	0	0	0	0	1995	0	0	0	0	0	0	0.0	0.0
Total energy released	316	429	204	345	2190	643	366	824	166	273	1194	332	1212

(See the Q2000_2010 spreadsheet for original version)

Here I have uplifted the calculated Terajoules to Petajoules to fit the display better. In terms of overall energy released 2010 is again higher than all other years except 2004 this time. The interesting thing is that whilst in terms of numbers (count) 2010 is pretty much level pegging with 2008, in terms of release it is only a little over half of the 2004 energy.

Taking a look at the energy per quake (which is not a particularly meaningful figure, just an indicator) we can see that 2010 still scores higher than all year other than 2004 – which is to be expected due to the massive magnitude 9 earthquake in 2004. You can see from the figures that this magnitude 9 released almost twice the amount of energy of the magnitude 8.8 in Chile.

See revisions at the end.

Quake number/energy ratio (Av energy/quake) in Terajoules											
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
5.0 - 5.99	9	8	8	9	9	8	7	7	7	8	7
6.0 -6.99	227	248	196	262	229	247	223	247	255	242	269
7.0 -7.99	14905	9909	13009	8542	4258	9412	8974	12069	9246	11108	6806
8.0 - 8.99	63096	251189	0	177828	89125	501187	120462	149040	0	63096	1000000
9.0+	0	0	0	0	1995262	0	0	0	0	0	0
Ratio totals	213	317	155	247	1301	345	195	360	84	179	603

In many respects 2010 can be equated to 2004 in that removing the one single large earthquake in each year then puts each year much lower down the league table, in fact almost at the bottom in each case in terms of energy.

See the comparison on the next page.

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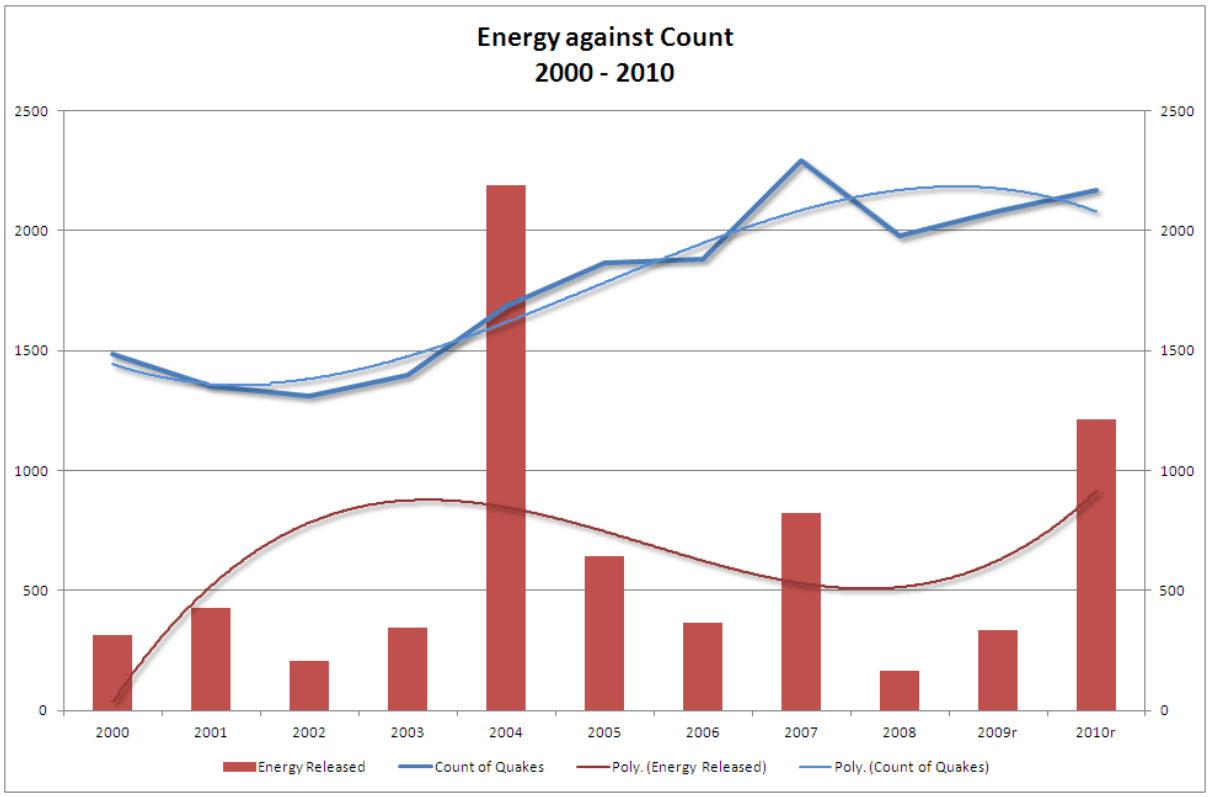
Raw Counts

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
5.0 - 5.99	1328	1222	1172	1241	1527	1716	1728	2095	1796	1920	1997
6.0 -6.99	140	115	125	141	140	139	142	178	168	144	151
7.0 -7.99	14	14	13	14	14	10	9	14	12	16	21
8.0 - 8.99	1	1	0	1	1	1	2	4	0	1	0
9.0+	0	0	0	0	0	0	0	0	0	0	0
Total Count	**1483**	**1352**	**1310**	**1397**	**1682**	**1866**	**1881**	**2291**	**1976**	**2081**	**2169**

Energy Released Petajoules (PJ)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Mag 5	12.3	10.3	10.0	10.6	13.5	13.4	12.7	14.9	12.7	12.8	14.0
Mag 6	31.7	28.5	24.5	36.9	32.1	34.3	31.7	44.0	42.8	33.4	40.8
Mag 7	208.7	138.7	169.1	119.6	59.6	94.1	80.8	169.0	111.0	196.8	157.1
Mag 8	63.1	251.2	0.0	177.8	89.1	501.2	240.9	596.2	0.0	89.1	0.0
Mag 9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total energy released	**315.8**	**428.7**	**203.6**	**344.9**	**194.3**	**643.0**	**366.1**	**824.0**	**166.4**	**332.1**	**211.9**

Note that doing this, 2004 and 2010 are almost bottom, with only 2008 – the quiet year – being lower in terms of energy release.

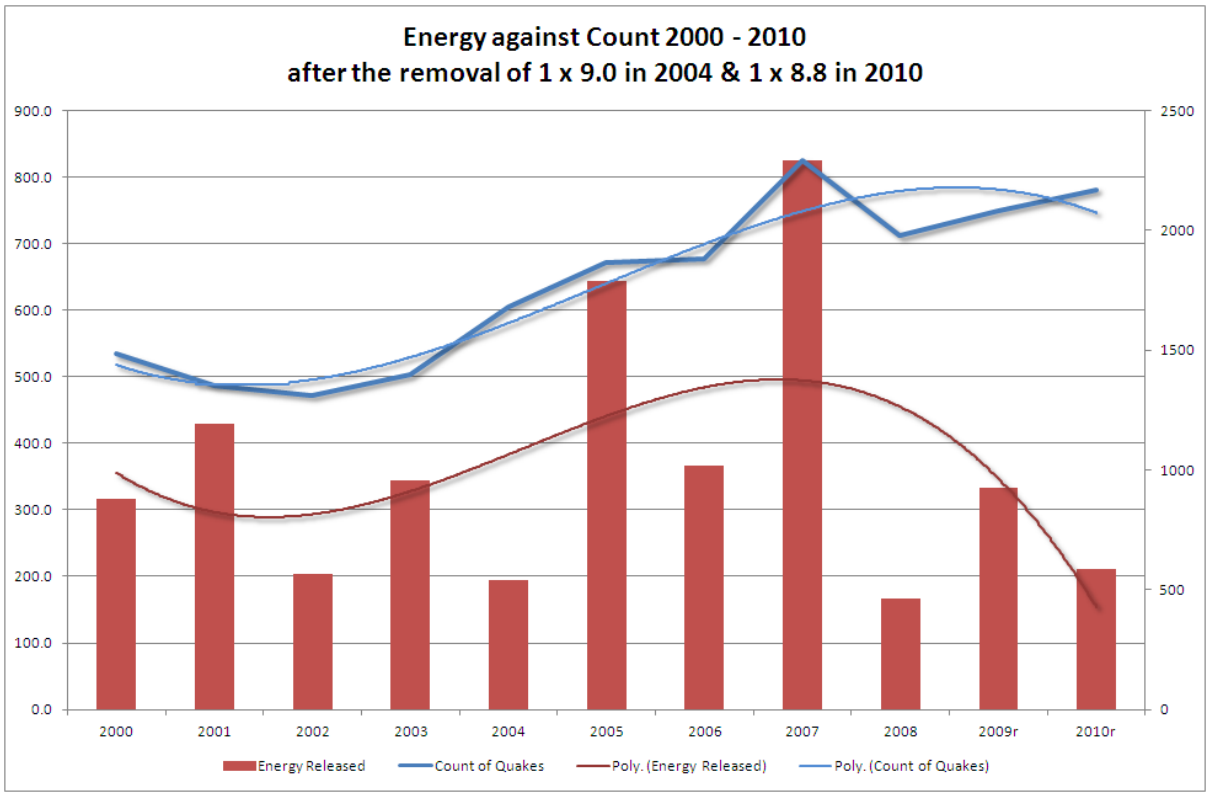


Combined chart of Energy released and earthquake counts.

Looking at the results like this it becomes immediately clear the impact that the single large earthquake in 2004 and 2010 respectively had upon the overall.

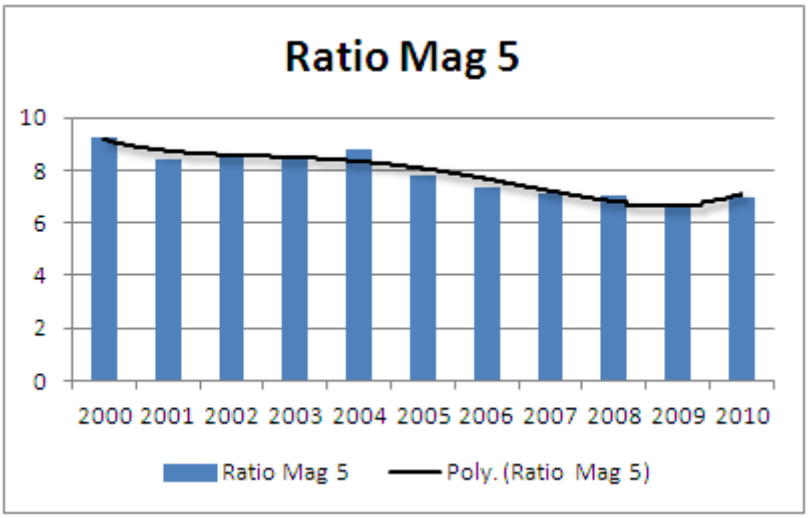
Without the one quake in those years the graph looks like this:

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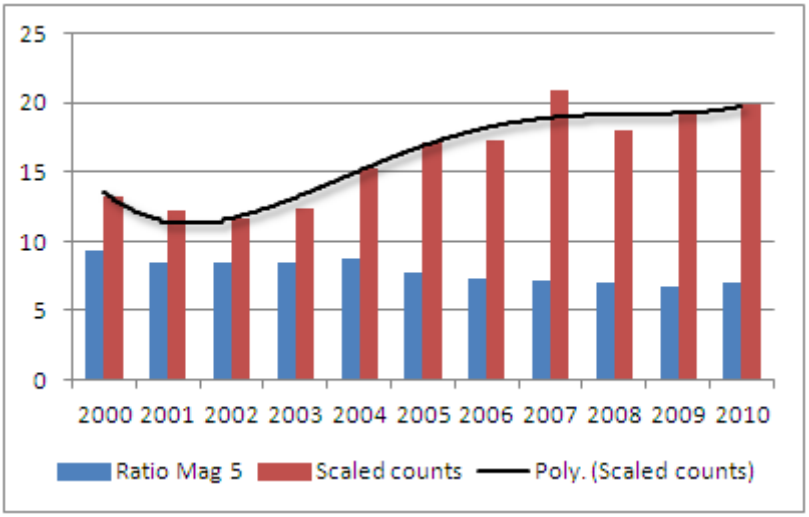
It may not be a proper results set, but it does illustrate just how powerful these larger earthquakes are in terms of energy.

Another comparison is average energy per quake. This is possibly a questionable figure in terms of realistic expectation, since you will never get an 'average' earthquake, but as a statistic it does give another overview on each earthquake band in each year. First take a look at Magnitude 5 earthquakes.

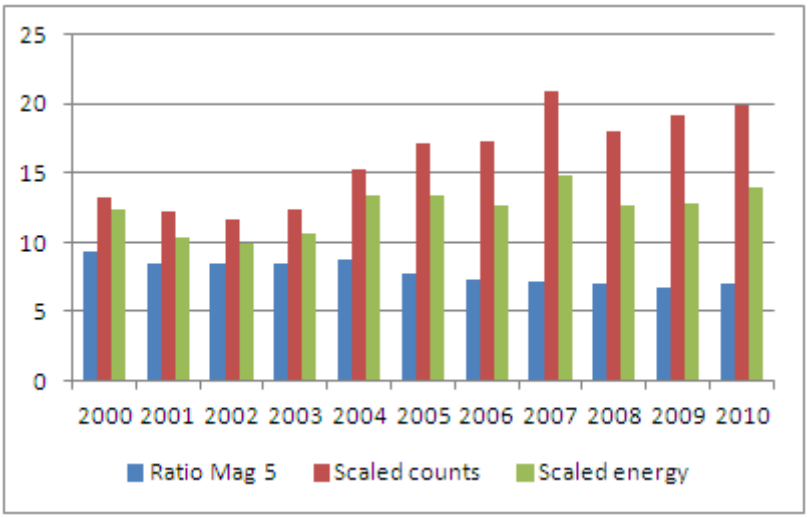


As you can see the average energy of magnitude 5 quakes has fallen over the decade and into 2010.

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I scaled the counts by a factor of 100 so that they did not swamp the graph. Now you can see above the counts alongside the ratio. As you can see the trend of magnitude 5 earthquakes rose up to 2005 and from then on through to present has flattened off. In fact the average is 1705 Magnitude 5 quakes from 2004 to 2010 so at 1920 magnitude 5.0 to 5.99 quakes this last year was hardly significant. It is higher against the 1520 for 10 years.

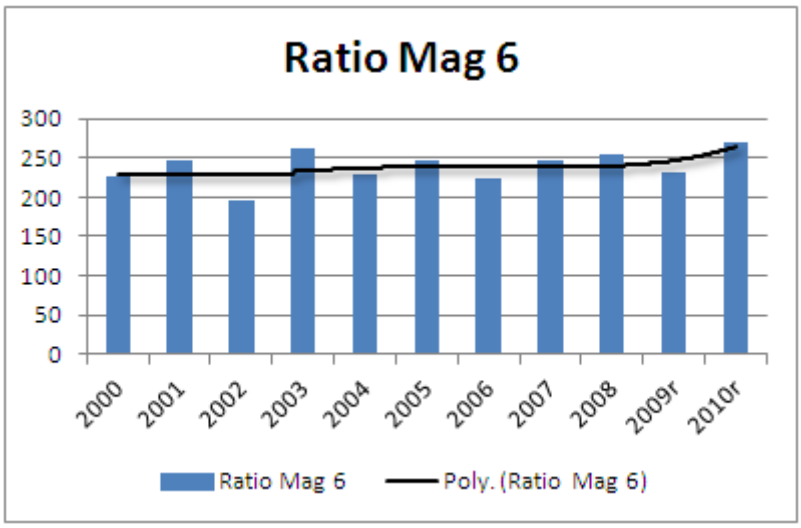


With the energy added you can now see why the overall ratio has fallen, and to be fair pretty much flattened out in the last few years. The average energy for magnitude 5.0 to 5.99 quakes over the 11 year period is 12.5 petajoules per year. 2010 @ 14 PJ is a little above the mark.

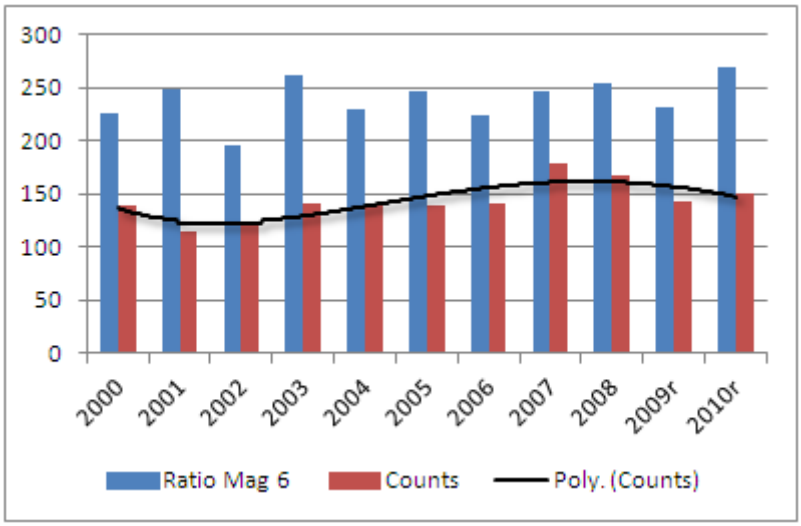
So how about Magnitude 6 quakes?

No real scares here, in fact the magnitude 6 figures are pretty flat for the most part with average ratio of 270 terajoules per quake for the 11 year period. 2001 weighs in at 269, which is only fractionally higher than the 2003 figure, but it has to be said that 2003 and 2010 are the top two. So let's look at the graphs for these:

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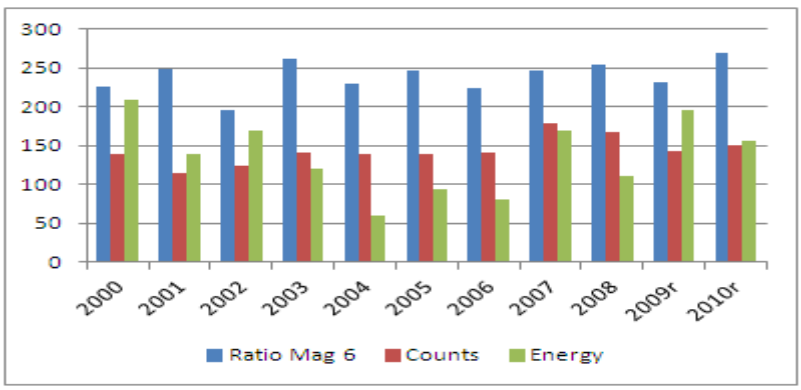


Now with the counts added:



Even though this line is not as 'straight' as the ratios, nevertheless the overall picture is of an even distribution of counts with the average raw counts for the 11 year period as 142. 2010 is not out from the average at all with 143 counted.

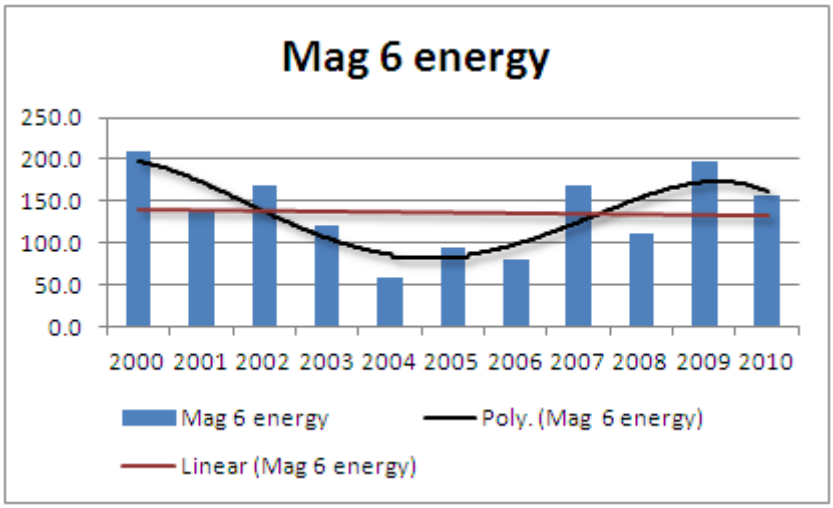
So now the energy added.



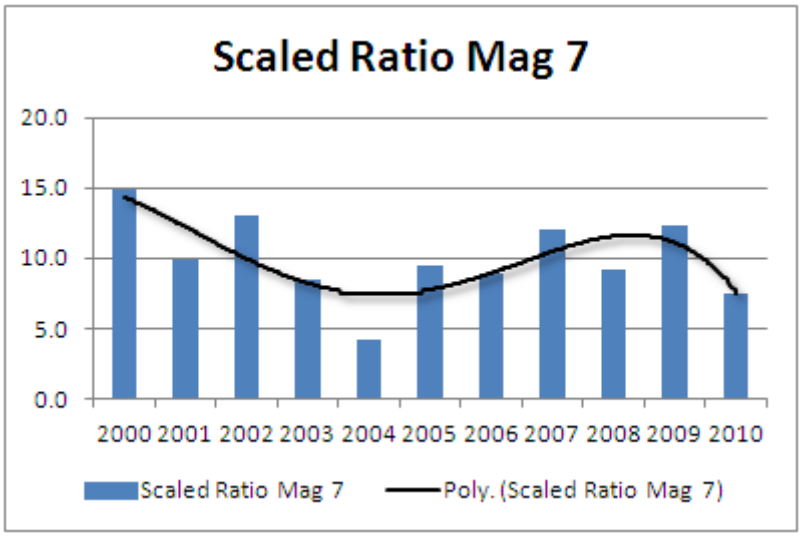
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Again this is not out of the ordinary as the average for the 11 years is 132 terajoules per magnitude 6 quake and the 2010 value is 142 terajoules.

The overall trend of 6.0 magnitude quakes over the eleven years is down as shown on this graph with a polynomial (4) trend and a linear trend together.

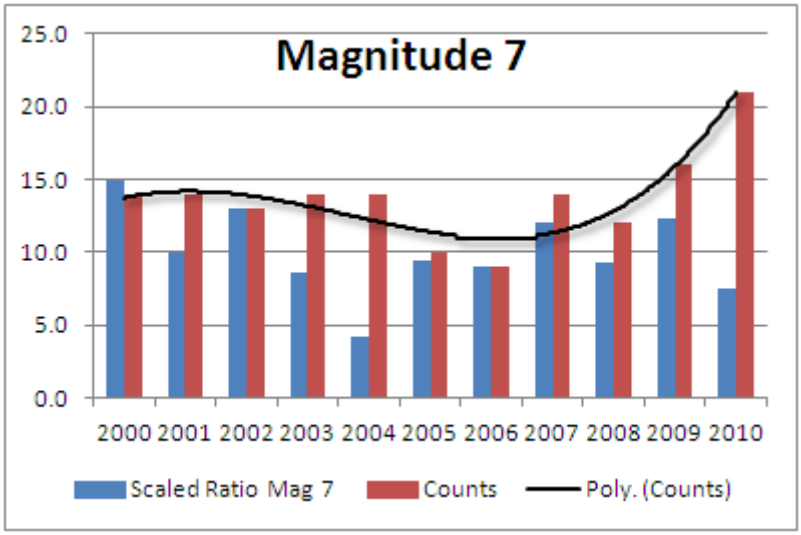


Moving on to Magnitude 7 earthquakes the ration gets interesting especially since 2004 and 2010 come out as the lowest ratios.



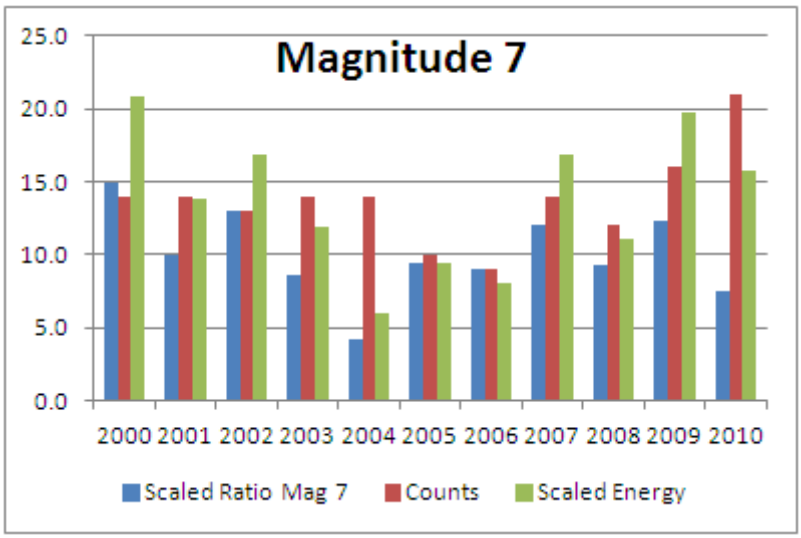
The ratios are showing a marked downwards trend, in other words the energy release of an average magnitude 7 earthquake appears to have decreased for 2010.

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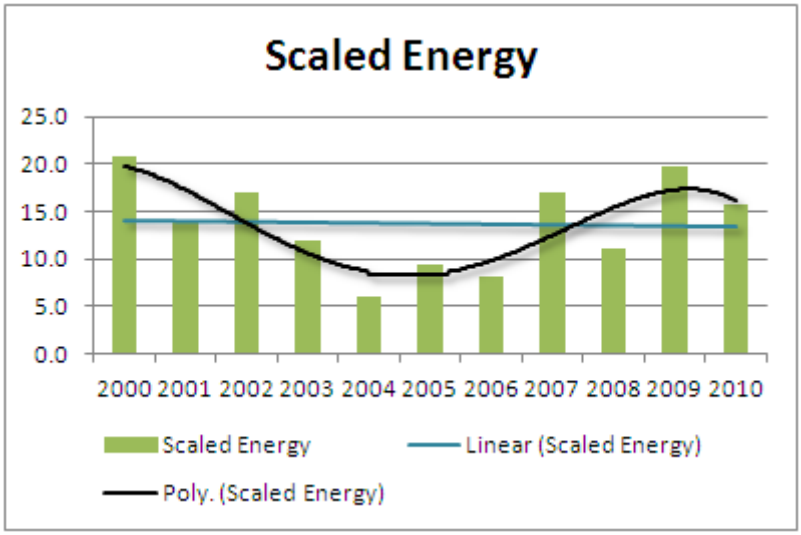
The count of the earthquakes is up, so that would explain the decrease in the ratio.

Provided that the energy released remains roughly an average for the year we can then conclude that magnitude 7 earthquakes are dropping in intensity.



At a casual glance the energy seems to have dropped down to 2004 and then built back up and levelled off thereafter. Let's take a look at the energy by itself. This is scaled down by a factor of 10 (making it Exajoules) in this graph and the one above.

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Here we see a slight downward linear trend, reflected in the polynomial of course.

Basically then for magnitude 7 earthquakes the count is up. The average for the 11 years is 14 magnitude seven earthquakes per year and 2010 weighs in at 21 – the highest figure in all of the eleven years.

The average energy in Exajoules for the eleven year period is 13.3, and 2010 is only just above that at 14.3. This is dwarfed by 2000 which was 20.9!

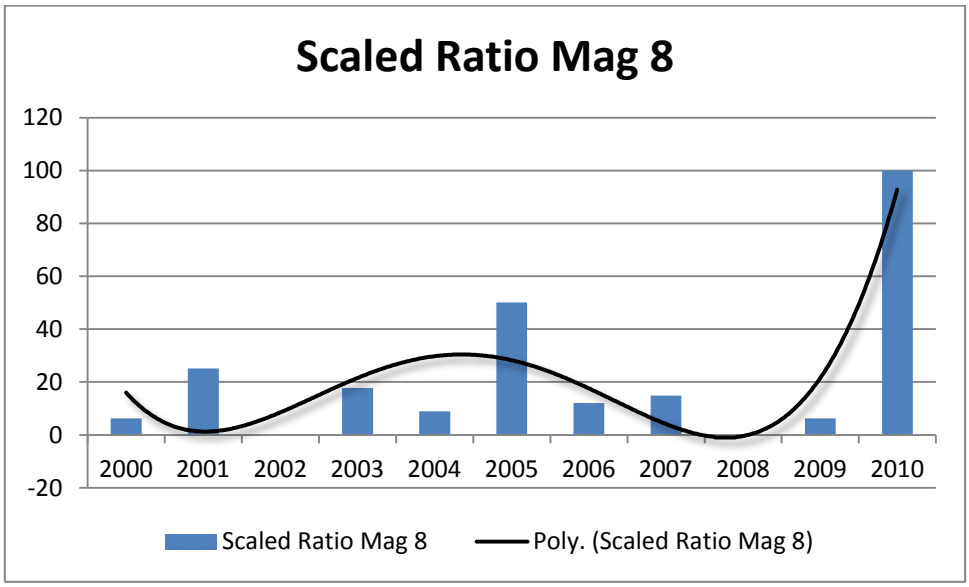
In fact in the energy release rankings 2010 is a second division team being only 7th highest out of 11 or if you prefer ranking 5th behind 2009, 2007, 2002 and 2000.

1	2004	5.96
2	2006	8.08
3	2005	9.41
4	2008	11.096
5	2003	11.96
6	2001	13.87
7	**2010**	**15.71**
8	2007	16.90
9	2002	16.91
10	2009	19.68
11	2000	20.87

Curiously again 2004 is the lowest.

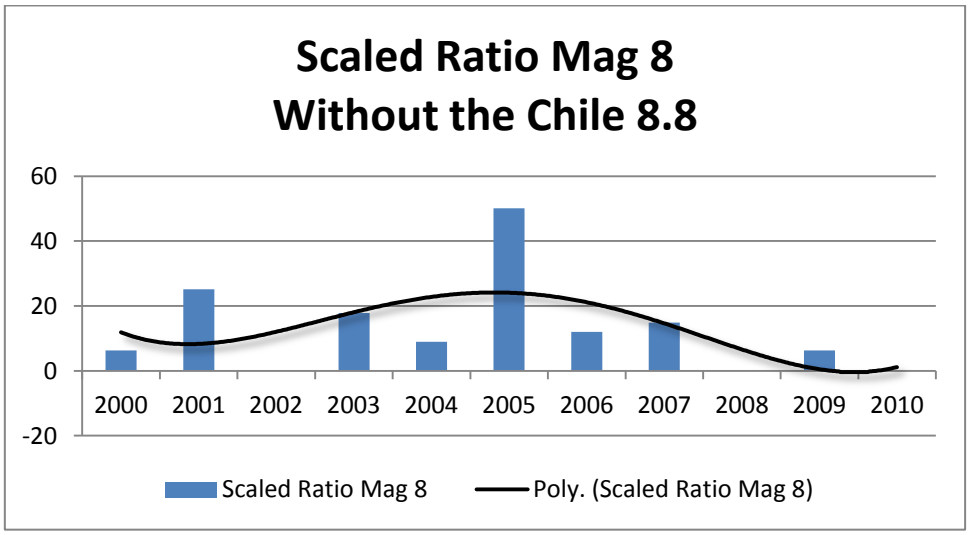
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Now we come to Magnitude 8. From this point on it is not really feasible to compare years as not every year has a magnitude 8 earthquake. Having said that there are only 2 years without a magnitude 8 so away we go….



This is of course being skewed by the Chile earthquake at magnitude 8.8 since that is so very nearly a magnitude 9.

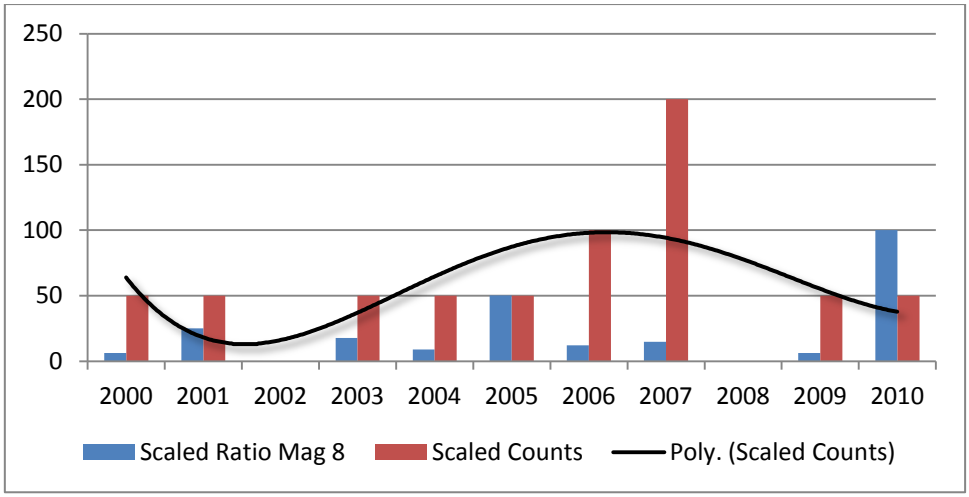
Just as a quick exercise what would this look like if the 8.8 had been a 9 and there were therefore no magnitude 8 quakes in 2010?

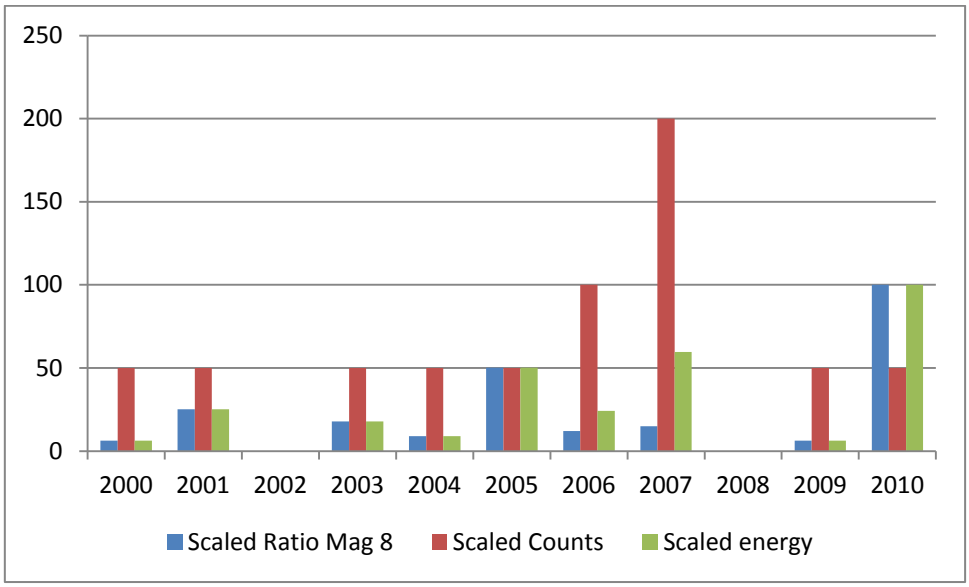


That makes quite a difference!

I am going to pass quickly through the next two without comment but I include them for consistency.

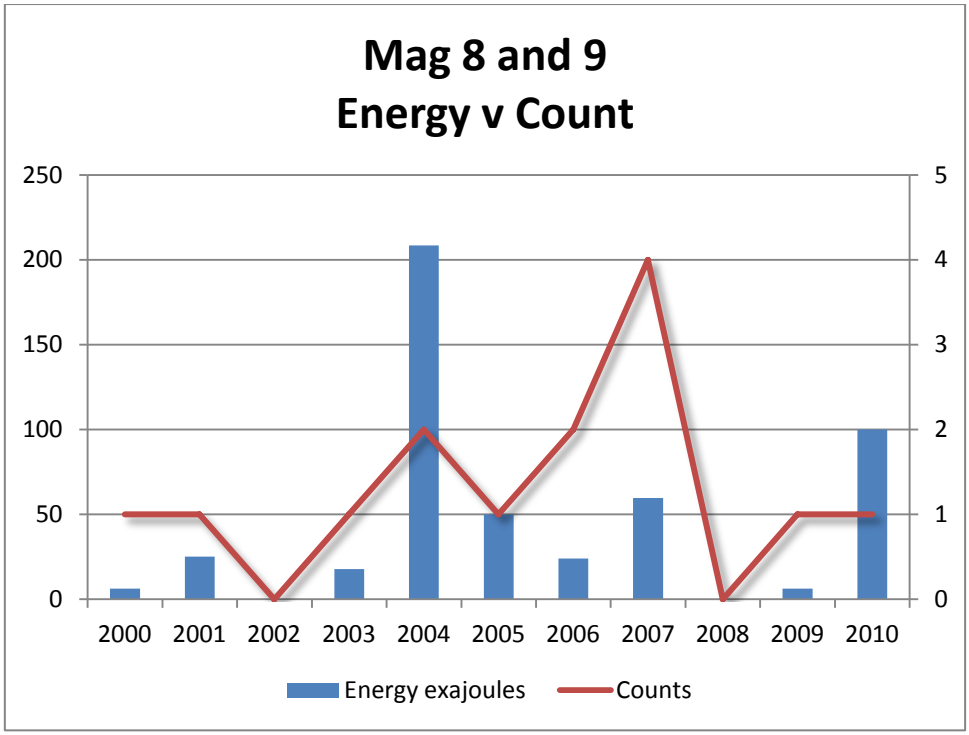
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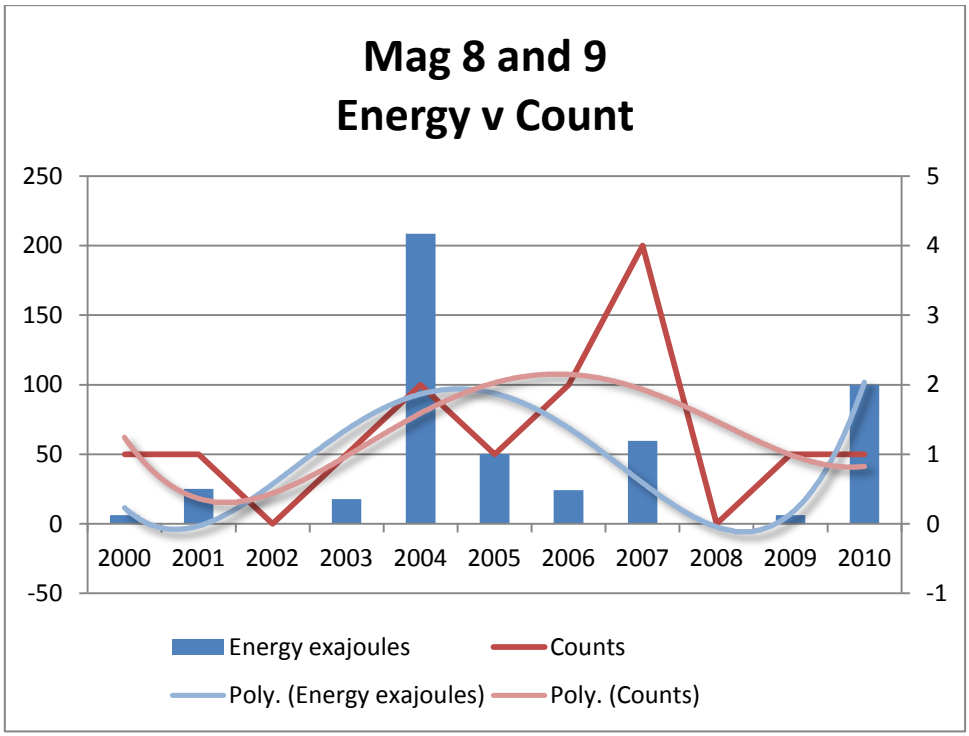
There is little point in showing a single 9 in the charts so I will now combine the 8 and 9 magnitudes.

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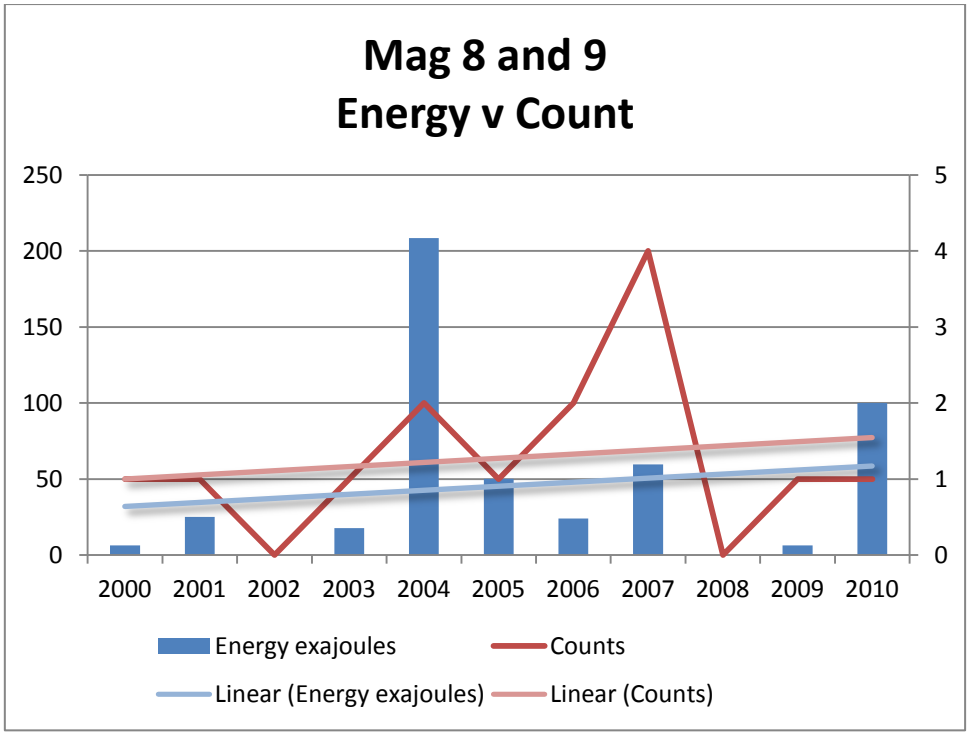
Energy on the left axis and counts on the right axis.

Here is the same graph with a trendline (polynomial 4) for each element.



Either linear or polynomial the trend over the 11 year period is slightly upwards for both number and energy released, but it must be said that the increase is not massive.

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The ratios of all the quakes together are below.

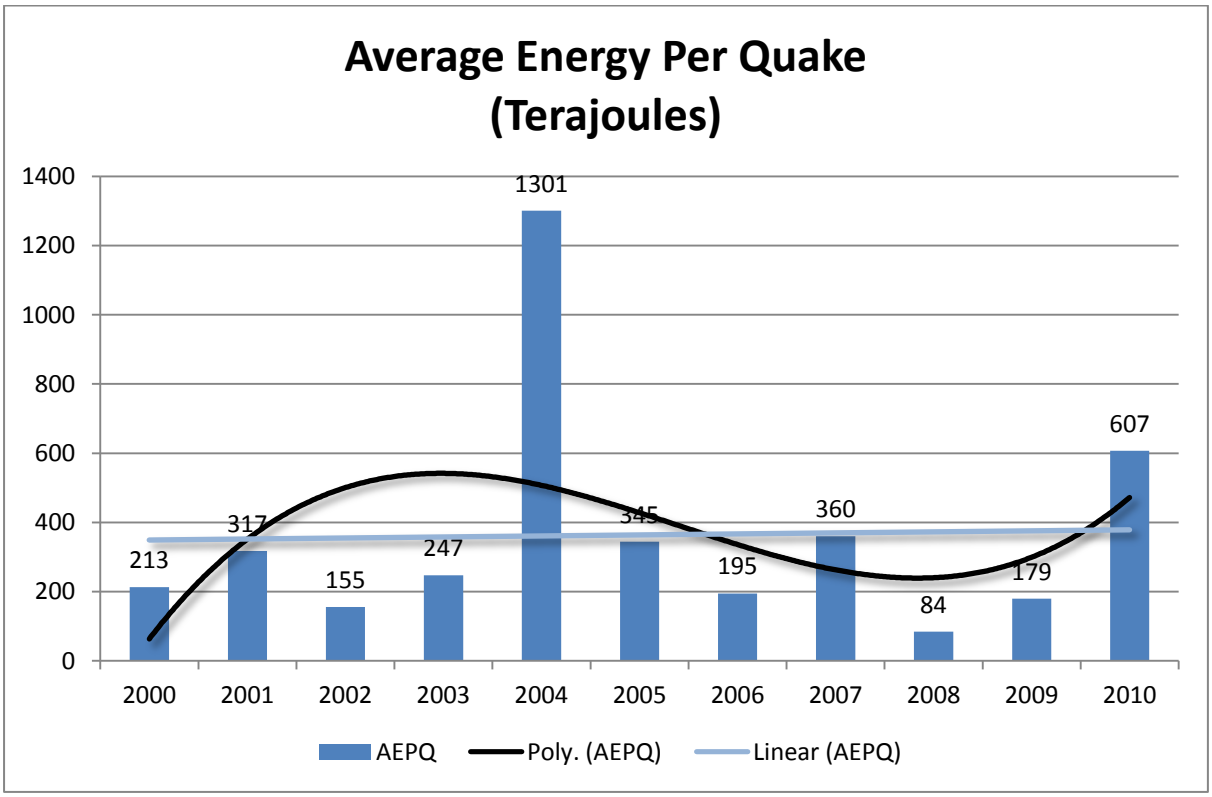
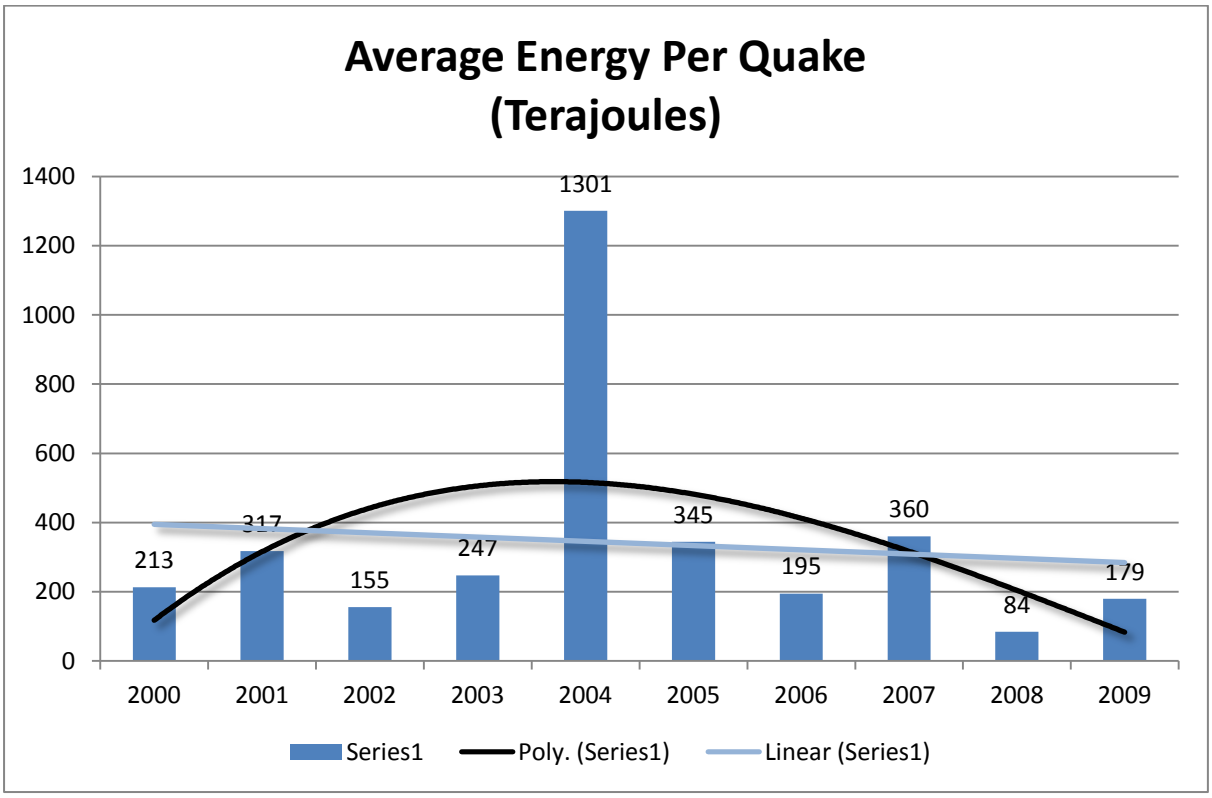


Chart of the Energy/Count ratio in Terajoules

This is a pretty minimal trend especially viewed as a linear trend and it could well be imagined that if history repeated itself and the overall energy falls for the next couple of years following the Chile earthquake, the trend could tip downwards.

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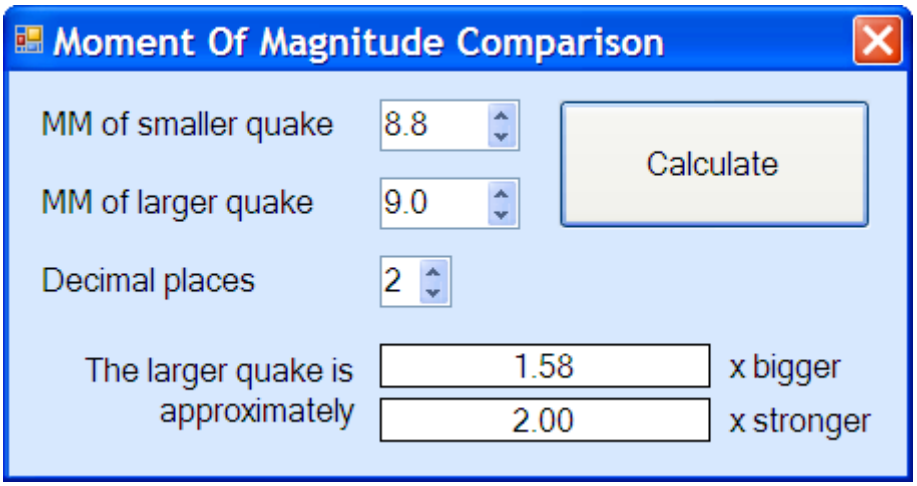
By removing 2010 from the chart one can see just how easily at these higher magnitudes a small change can have a great influence.



Years 2000 to 2009 only

In conclusion therefore, in my opinion as a non-scientist, I believe that 2010 in terms of earthquakes was not a particularly outstanding year.

Whilst it was the second highest of the eleven years in term of energy released, the energy was well below that of 2004 because the 9.0 was one and a half times bigger than the 8.8 but twice as strong.



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I believe that much of the 'unrest' was occasioned by the Chile earthquake which shook things up a bit and I am reasonably sure that we will see a settling down over the next two or three years.

In theory it should be possible to do this exercise with another provider – for example EMSC and whilst there are times when the EMSC data returns a higher magnitude than the USGS, there are also times when it is the other way round. I believe that the outcome would not be significantly different. It is an exercise I shall be carrying out during 2011.

We are all very grateful to the USGS and other providers of information on seismology for making this available to us. In many respects the freely available information is a part of the cause in my opinion of why the impression that things have got much worse on the earthquake front abounds.

Take for example the LISS helicorder page. This is a great facility, but then there is a deep 6 or 7 and all the recorders go black. Then people start asking why there are so many earthquakes when there is of course only one. You will find a couple of examples from 2010 on my 4Shared site. Here you will also find the spreadsheet files that go with this document.

Earthquake Analysis 2010 folder on 4Shared

A little knowledge is a dangerous thing. ☺ So armed with a little knowledge I have produced a web page that anyone can use to learn about how seismographs work and how the epicentre of an earthquake is determined. I have to say that this is put together by me but the content is by IRIS and others. There are some exercises and links to further reading at the end.

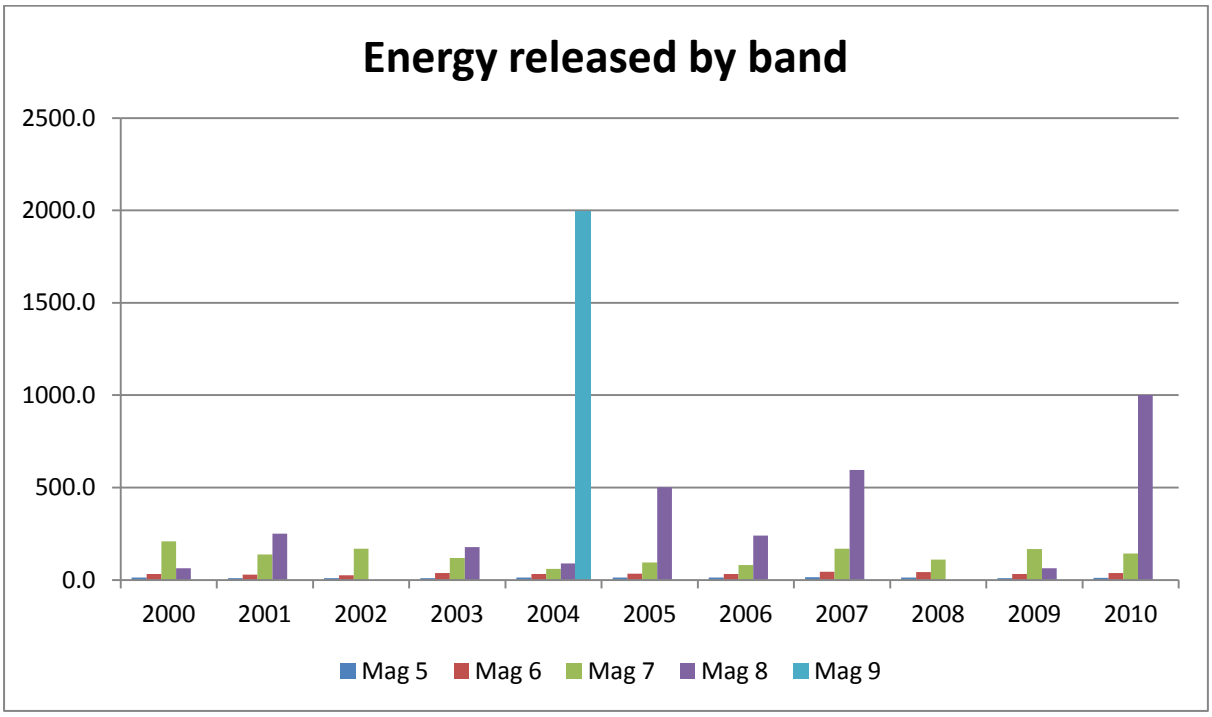
Overall rankings

	1	2	3	4	5	6	7	8	9	10	11
Counts	2001	2010	2008	2006	2005	2004	2009	2000	2003	2001	2002
Energy	2004	2010	2007	2005	2001	2006	2003	2000	2009	2002	2008

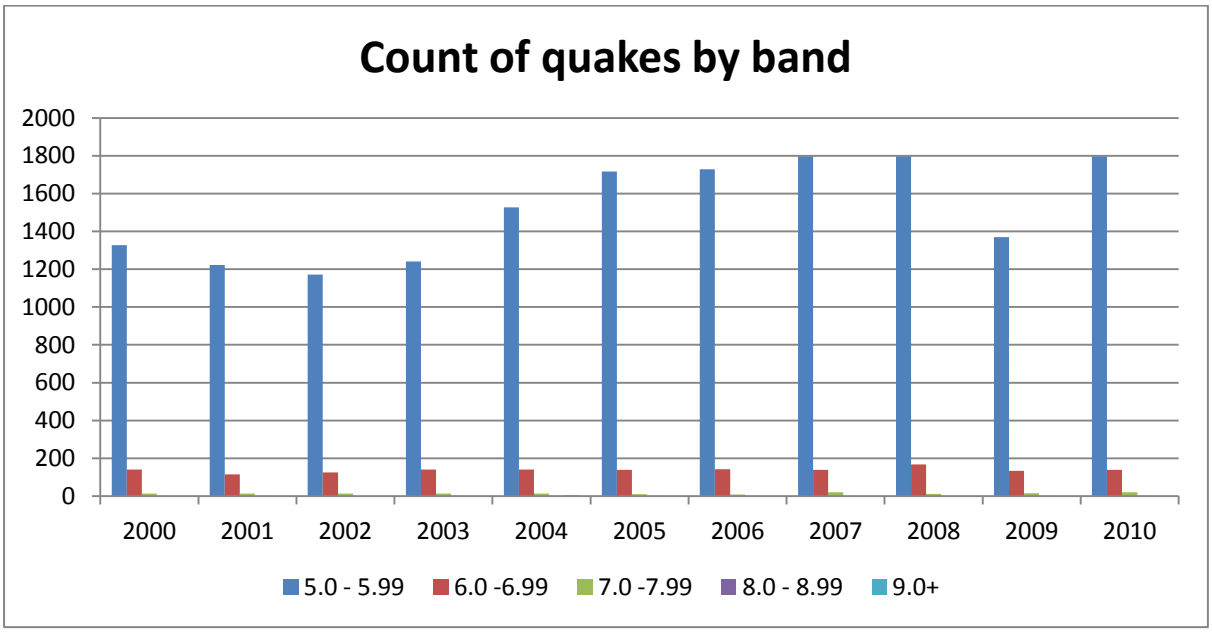
David Loring
The Republic Of Ireland
January 2011

A couple of supplemental charts follow purely for interest. All of these can be found in the spreadsheets.

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The energy release band by band showing the single 9.0 magnitude earthquake in the 11 year period.



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Energy Released Petajoules (PJ) Mag 8/9 only											
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Mag 8	63.1	251.2	0.0	177.8	89.1	501.2	240.9	596.2	0.0	63.1	1000.0
Mag 9	0	0	0	0	1995	0	0	0	0	0	0
Total energy released	**63**	**251**	**0**	**178**	**2084**	**501**	**241**	**596**	**0**	**63**	**1000**

Data sources:

Source	Data
Centennial catalogue USGS.	2000 to 2001 inclusive Magnitude 6+. This data was extracted into centcat_2000 and centcat_2001
The ANSS catalogue online was used for collecting the data for 2000 and 2001 for magnitude 5 to 5.99 earthquakes only.	catsearch2000_5, catsearch2001_5
The ANSS catalogue on line was used for all other years between.	catsearch2002, catsearch2003, catsearch2004, catsearch2005, catsearch2006, catsearch2007, catsearch2008
QVS Data collection	Magnitude5plus_2009 and WWQuakes2010_5plus
The results set.	Q2000_2010
Note: These are available in either xlsx or xls formats	

Data Links:

The USGS Centennial Earthquake catalog web page

The Centennial Catalog (Engdahl and Villaseñor, 2002) (2.75MB PDF) is a global catalog of locations and magnitudes of instrumentally recorded earthquakes. It has been updated, and currently extends from 1900 to April 2002. It is being periodically updated as new arrival time data for recent years become available.

The ANSS Catalog Search web page

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Revised Raw Counts for 2009/2010

Raw Counts													
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2009r	2010r
5.0 - 5.99	1328	1222	1172	1241	1527	1716	1728	2095	1796	1370	1816	1920	1997
6.0 -6.99	140	115	125	141	140	139	142	178	168	134	143	144	151
7.0 -7.99	14	14	13	14	14	10	9	14	12	15	21	16	21
8.0 - 8.99	1	1	0	1	1	1	2	4	0	1	1	1	1
9.0+	0	0	0	0	1	0	0	0	0	0	0	0	0
Total Count	**1483**	**1352**	**1310**	**1397**	**1683**	**1866**	**1881**	**2291**	**1976**	**1520**	**1981**	**2081**	**2170**

Revised Energy for 2009/2010

Energy Released Petajoules (PJ)													
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2009r	2010r
Mag 5	12.3	10.3	10.0	10.6	13.5	13.4	12.7	14.9	12.7	10.6	12.5	12.8	14.0
Mag 6	31.7	28.5	24.5	36.9	32.1	34.3	31.7	44.0	42.8	32.5	38.5	33.4	40.8
Mag 7	208.7	138.7	169.1	119.6	59.6	94.1	80.8	169.0	111.0	166.6	142.9	196.8	157.1
Mag 8	63.1	251.2	0.0	177.8	89.1	501.2	240.9	596.2	0.0	63.1	1000.0	89.1	1000.0
Mag 9	0	0	0	0	1995	0	0	0	0	0	0	0.0	0.0
Total energy released	**316**	**429**	**204**	**345**	**2190**	**643**	**366**	**824**	**166**	**273**	**1194**	**332**	**1212**

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Other revised data

Quake number/energy ratio (Av energy/quake) in Terajoules													
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2009r	2010r
5.0 - 5.99	9	8	8	9	9	8	7	7	7	8	7	7	7
6.0 -6.99	227	248	196	262	229	247	223	247	255	242	269	232	270
7.0 -7.99	14905	9909	13009	8542	4258	9412	8974	12069	9246	11108	6806	12300	7480
8.0 - 8.99	63096	251189	0	177828	89125	501187	120462	149040	0	63096	1000000	89125	1000000
9.0+	0	0	0	0	1995262	0	0	0	0	0	0	0	0
Ratio totals	213	317	155	247	1301	345	195	360	84	179	603	160	558

Energy Released Petajoules (PJ) Mag 8/9 only													
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2010	2010
Mag 8	63.1	251.2	0.0	177.8	89.1	501.2	240.9	596.2	0.0	63.1	1000.0	89.1	1000.0
Mag 9	0	0	0	0	1995	0	0	0	0	0	0	0	0
Total energy released	63	251	0	178	2084	501	241	596	0	63	1000	89	1000

Raw Counts Mag 8/9 only													
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2010	2010
8.0 - 8.99	1	1	0	1	1	1	2	4	0	1	1	1	1
9.0+	0	0	0	0	1	0	0	0	0	0	0	0	0
Total Count	1	1	0	1	2	1	2	4	0	1	1	1	1

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