

Statistical Evaluations about Analysis of Seismic Data to Perform Comparisons among Different Seismogenetic Areas

*Valutazioni Statistiche sull'analisi di Dati Sismici per il
Confronto di Diverse Aree Sismogenetiche*

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Riassunto: Il presente articolo si propone di esaminare la variabilità del fenomeno sismico sia da un punto di vista territoriale che temporale. E' stata infatti effettuata un'analisi comparativa di tipo territoriale, confrontando il numero e l'intensità di scosse verificatesi in zone considerate particolarmente a rischio (quali il Giappone, il Sud America e la Nuova Guinea) e a tal scopo è stata applicata la metodologia non parametrica di test di permutazioni dipendenti (NPC test). Altresì, è stata condotta l'analisi temporale, in cui si è mostrata la possibilità di prevedere forti scosse secondarie attraverso le anomalie riscontrate nel decadimento temporale di sequenze di aftershocks; a tal fine è stato utilizzato il metodo "delta/sigma", basato su un processo non-stazionario di Poisson.

Keywords: Seismic Sequences, NPC Test, Non-Stationary Poissonian Process

1. Introduction

Three basic types of plate boundaries are characterized by different modes of plate interaction: divergent, convergent and transcurrent boundaries. In this paper we would like to focus attention on convergent boundaries and in particular on subduction zones (more than 90% of world's convergent boundaries are subduction zones). The seismicity in these zones accounts for 70% of the annual global seismic energy release. Biggest earthquakes occur along these boundaries. Here we analyzed data of three different subduction zones: the Southern America, the Japanese and the New Guinea areas. The main goal of the present paper is to study the seismic phenomena highlighting possible differences among different seismogenetic areas. This kind of analysis is principally related to different magnitude classes. Following the approach firstly proposed by D'Amico et al. (2004), and usefully applied to many seismic sequence (see for example Caccamo et al. 2005), we have studied the behavior of some seismic sequences following a mainshock having magnitude greater than 7. In order to highlight the clustering, especially in time, we have calculated the fractal dimensions D_0 and D_2 the box-counting and the correlation dimension respectively (D'Amico et al., 2005). Here we have used coming from NEIC-USGS data base. The analysis has been focused on 159.000 earthquakes having magnitude greater or equal to 5, that happened

in the period between the 1st January 1973 to 30th November 2006 in the above mentioned areas.

2. Methodology

In order to analyze the seismicity of the three different areas we have used a nonparametric approach, because this kind of phenomena could not guarantee asymptotically valid results; so, we used a permutation approach. To highlight statistically significant differences among the areas, we have applied the NPC test (Pesarin, 2001); this procedure allows us to verify directional hypotheses solving the problems related to restricted alternative hypotheses. It could be also considered multistrata, because allow us to verify the hypotheses for every strata: in this paper we have divided data into three M magnitude classes ($5 \leq M < 6$; $6 \leq M < 7$ and $M \geq 7$). Furthermore we have selected some seismic sequences inside the above mentioned regions according the criteria in detail described by D'Amico et al. (2004) and Caccamo et al. (e.g.2005), applying the so called "delta/sigma method" to investigate seismic anomalies in the temporal decay of seismic sequence. It estimates the difference between values of the observed and theoretical temporal trend. Here we analyzed the behavior of seismic sequences happened in the studied regions. We also provided to study the fractal dimensions D_0 and D_2 (D'Amico et al.,2005), in order to highlight the clustering in time of aftershock.

3. Results and Conclusions

We have verified, in a inferential way, the existence of statistically significant differences among events in the three different areas, for each investigated magnitude class. In particular, we have verified that the number of upper magnitude events in Japan is statistically higher than the New Guinea ones, but it is quite similar in Southern America. The lower magnitude events are predominant in New Guinea zone; this could be directly in relation with the local condition and the minor faults in this area. Concerning the delta/sigma method we notice that there are some significative anomalies in the temporal decay before the occurrence of large aftershocks. For example in the Loyalty Islands seismic sequence of the December 27, 2003 $M=7.3$ we highlighted that the sequence have an aftershock with magnitude greater than 5.5 on the 17-th day after the mainshocks and we found an anomaly at the 12-th day. We also have highlighted the clustering in time of aftershock studing the fractal dimensions D_0 and D_2 .

References

- Caccamo D., Barbieri F. M., D'Amico S., Laganà C., Parrillo F. (2005). Temporal series of the New Guinea 29 April 1996 aftershock sequence. *PEPI*, vol. 153, 4, 175-180.
- D'Amico S., Caccamo D., Barbieri F., Laganà C. (2004) Some methodological aspects related to the prediction of large aftershocks, *E.S.C. 2004, Book of Abstracts* 132-133
- D'Amico S., Caccamo D., Barbieri F. M., Parrillo F., (2005) Use of fractal geometry for a study of seismic temporal series, *Geophys.Res Abs.*, Vol. 7, 1607-7962
- Ogata, Y. (1988), Statistical models for earthquake occurrences and residual analysis for point processes, *Journal of the American Statistical Association*, 83, 9-27.
- Pesarin F. (2001) *Multivariate permutation tests with applications in biostatistics*. Wiley, Chichester.