Application of physical and stochastic models of earthquake clustering to regional catalogs

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We show how a previously existing clustering model can be modified by the application of the rate-and-state theory. This application has allowed reducing the number of free parameters of the model, giving at the same time a physical meaning to each of them.

1. Introduction

The increase of occurrence probability for seismic events close in space and time to other previous earthquakes has been modeled both by statistical and physical processes. From a statistical viewpoint the so-called epidemic model (ETAS) introduced by Ogata in 1988 and its variations have become fairly well known in the seismological community (Ogata, 1998; Console and Murru, 2001; Console, Murru, and Lombardi, 2003). Tests on real seismicity and comparison with a plain time-independent Poissonian model through likelihood-based methods have reliably proved their validity.

On the other hand, in the last decade many papers have been published on the so-called Coulomb stress change principle, based on the theory of elasticity, showing qualitatively that an increase of the Coulomb stress in a given area is usually associated with an increase of seismic activity. More specifically, the rate-and-state theory developed by Dieterich in the '90s has been able to give a physical justification to the phenomenon known as Omori law. According to this law, a mainshock is followed by a series of aftershocks whose frequency decreases in time as an inverse power law.

2. Application to Japanese and Italian earthquakes

In this study we give an outline of the above-mentioned stochastic and physical models, and build up an approach by which these models can be merged in a single algorithm and statistically tested (Console, Murru, and Catalli, 2005; Console, Murru, Catalli and Falcone, 2005). The application to the JMA catalog from 1970 to 2003 shows that the new model incorporating the physical concept of the rate-and-state theory performs not worse than the purely stochastic model with two free parameters only, while the application to the Italian seismic catalog collected by the National Institute of Geophysics and Vulcanology (INGV) for the period from 1987 to 2005 shows that the new model incorporating the physical concept of the rate-and-state theory performs not better than the purely stochastic model.

3. Conclusion

The better performance obtained with the new model on Japanese dataset with respect to Italian catalog can be explained by the different magnitude threshold of the two catalogs (larger for Japan than for Italy) and by the fact that the location errors in the Italian catalog are larger than the physical dimension of the earthquake sources in the low magnitude range.

6. References

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