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Research on the Aftershock Series for the past 10 years in the Japan Trench

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We analyzed the aftershock series for each individual M6-8 class earthquake in the Japan Trench for the period between October 1997 and November 2010. The purpose is to detect the stress state for the occurrence of the M9 earthquake. We approximated time variation of the number of each of the aftershock series from JMA hypocenter (final solution) data to the modified Omori's law. Furthermore, we compared with P values and existing research results about the stress state.

1. Introduction

On March 11 2011 the M9 earthquake occurred. Prior to that, it was not considered that there had been enough stress storage for the occurrence of a M9 class earthquake in the area from its history and distribution of asperity that inferred from waveforms by past earthquakes and GPS displacement data.

Aftershocks generally occur due to redistribution of stress by the mainshock. We have thought that the stress building up situation that could have caused the M9 earthquake might influence the aftershock activity. In this study, we analyzed each aftershock series spatially and temporally, and sought the relationship between the aftershock and the stress state.

2. Method

First we picked up M6 or larger earthquakes. Then we determined each aftershock series from its spatial and temporal distribution. Next we applied the modified Omori's law (below) to the each aftershock series making the logarithmic graph with the number of aftershock each day and elapsed days since the mainshock.

$N(t) = K/(t+C)^P$, where:

N(t): Number of aftershock per unit time.
t: Elapsed time since the mainshock
K: Number scale of the aftershock
C: Difficulty of the aftershock to occur immediately after the mainshock, and C=0 in this study.
P: Decay rate of the aftershock

This law means that the aftershock decreases exponentially.

3. Result and Discussion

We found some aftershock series that may not be approximated to the law. Hereafter, we describe the aftershock series of inter plate earthquakes with P and K from 0.4 to 1.5 and from 1 to 300, respectively.

3.1. Earthquake with Afterslip

We focused four earthquakes with significant afterslip which were reported by Suito et al. 2011. The P values of their aftershock series tend to be smaller than average, meanings that the decay rate is slow. It suggested the relationship between aftershock and afterslip.

3.2. Significance

It was decided that the results with K values less than 10 are not fairly evaluated. The following are three tendencies on the approximation by smaller K values, meaning that the number of the aftershock is not enough:

- Results greatly depend on the definition of aftershock periods. Thus the reliability is low.
- Number of aftershocks varies significantly, do not show exponential decay.
- Difficult to determine P value

3.3. Correlation

Correlations between P values or K values and M of the main shock are as follows:

- A positive correlation between K values and M
- A negative correlation between P values and M

3.4. Locked Zone

We compared with P values and distribution of locked zone in Tohoku region that were geodetically observed before the M9

earthquake. As a result, it seems that the aftershock series with smaller P values distribute around the locked zone.

4. Conclusion

In this study, we estimated two parameters of the modified Omori's law, P and K, for each aftershock series and then considered the relationship between M and them. The area with small P value is coincident with the inter-plate coupled area before the subsequent megathrust earthquake. Further research based on existing studies such as slip state dependent friction law will help us to understand what this coincidence physically means.

Keywords: the Japan Trench, aftershock, the modified Omori's law, P value, K value, stress state