Terr. Atmos. Ocean. Sci., Vol. 19, No. 3, 235-240, June 2008 doi: 10.3319/TAO.2008.19.3.235(T)

A Study of the Unified Scaling Law of Earthquakes in the Taiwan Region

Ching-Yi Tsai[1] and Chiou-Fen Shieh[1, *]

[1] *Institute of Seismology and Applied geophysics, National Chung-Cheng University, Chiayi, Taiwan, ROC*

Received 2 March 2007, accepted 6 August 2007

ABSTRACT

The unified scaling law (also called the BCDS model), merges: (1) Omori's Law, (2) Gutenberg-Richter's law, and (3) the geometrical fractal distribution of epicenters, all of which, in combination, investigate the occurrence of earthquakes from a spatial-temporal perspective. This study plans to verify important questions arising from the definition of the BCDS model by doing three experiments. Firstly, we examine the feasibility of applying this model to Taiwan using different cell sizes and cut-off magnitudes. Secondly, we ascertain the difference between aftershocks and main shocks in a unified scaling law by comparing earthquake time sequences with declustered ones. Thirdly, we investigate the differences among scaling relationships obtained from various geological settings in Taiwan.

Our results show that no matter how cell size and cut-off magnitude change, they produce a very similar pattern symbolizing the scaling law. Using a Z-map, after declustering, the constant part, which is an apparent indicator of the characteristics of aftershocks, disappears, and the slope of the fast decaying part, which corresponds to the main shock, remains almost the same. In addition, scaling laws obtained from four different sub-regions in Taiwan, although slightly different to each other, all show to be of a similar scaling law.

Key words: Scaling law, Fractal distribution, Earthquakes

Citation: Tsai, C. Y. and C. F. Shieh, 2008: A study of the unified scaling law of earthquakes in the Taiwan region. Terr. Atmos. Ocean. Sci., 19, 235-240, doi: 10.3319/TAO.2008.19.3.235(T)

1. INTRODUCTION

The nature of the spatial-temporal phenomenon of earthquake occurrences is a complicated one. It is easier as well as more important for seismologists to understand the correlation among earthquakes over a long period of time than to just study an individual isolated earthquake. Despite the complexity of the phenomenon, clues arising from studies must be examined in detail to better understand earthquake occurrence. Firstly, the relationship between time and earthquakes according to Omori's Law (Omori 1895) is such that the frequency of aftershocks decreases with time after a main shock, thereby precisely indicating the existence of a power law. Similarly, when we look at the relationship between earthquake occurrences from the point of view of time and space, the appearance of a power law can be deduced from the Gutenberg-Richter law (Gutenberg and Richter 1944). Accordingly, the frequency of earthquake occurrence changes with the magnitude threshold of the earthquakes occurring in a certain area. These two power-law relationships between the waiting time and magnitude of earthquakes can be considered as a form of scale invariance in time and energy. This scale invariance is also shown in the spatial distribution of earthquakes. Hence, several seismologists (Okubo et al. 1987; Kagan and Jackson 1994; Marsan et al. 2000) consider spatial distributions of the epicenters of earthquakes to be fractal, though at times earthquakes may show significant deviation from this pattern.

Although earthquakes display complex spatial-temporal behavior, statistical evidence shows that several self-similarity properties can be found. Bak et al. (2002) and Christensen et al. (2002) pioneered an innovative model, called the BCDS model, to interpret the spatiotemporal distribution of earthquakes by merging: (1) Omori's Law, (2) the Gutenberg-Richter law, and (3) the geometrical fractal distribution of epicenters; thereby creating a unified scaling law. In brief, only a critical phenomenon exhibits a power

* *Corresponding author*
E-mail: seifent@eq.ccu.edu.tw