Nat. Hazards Earth Syst. Sci., 7, 343–344, 2007
www.nat-hazards-earth-syst-sci.net/7/343/2007/

Natural Hazards and Earth System Sciences

Book Review of "Fractal Analysis for Natural Hazards"

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FRACTAL ANALYSIS FOR NATURAL HAZARDS, EDITED BY: CELLO, G. AND MALAMUD, B. D., GEOLOGICAL SOCIETY, LONDON, SPECIAL PUBLICATION 261, 184 PAGES, 978-1-86239-201-4, 110.00 €, 2006.

Many natural objects in the Earth, like rock fractures or drainage networks, have a fractal geometry. However, in spite of the idea of self-similarity and fractals was formalized in 1967, its application in the study of natural hazards has not been accepted until recently. This book shows twelve excellent papers based on the contributions presented in a scientific session at the 32nd International Geological Congress held in Firenze, Italy, August 2004. These papers show the application of spatial and temporal fractal-related approaches and techniques to landslides, wildfires, floods, catastrophic rock fractures and earthquakes. A total of 37 scientists from UK, USA, Japan, China, France, Italy, Greece, Czech Republic, Norway, Australia and New Zealand, have contributed to this complete book that is indispensable for all those interested in the use of fractal analyses for the better understanding of natural hazards.

The book brings together two kinds of contributions: six papers are focused on methodology, like cellular-automata models or prediction and self-organizing behaviour; other six papers apply a specific methodology over some cases of study and regions, mainly Italy and Greece. Five papers are devoted to seismic activity, and other five contributions, to crustal stress or failures in rocks; two papers contemplate landslides and the same number considers wildfires; finally, one paper is devoted to floods analysis.

Between the methodological contributions, the first paper, by Malamud and Turcotte, provides a comprehensive lecture of the frequency-magnitude statistics for natural hazards, primarily on the basis on the power-law frequency-area behaviour of earthquakes, landslides and wildfires. The authors present the role of metastable regions in CA (cellular-automata) models in order to introduce an inverse-cascade model for metastable cluster coalescence. This is the only contribution in the book that shows a common approach to three different hazards. The paper by Ley proposes a model to explain the three phases of pre-failure damage process in granitic rocks. The contribution shows the experimental study by acoustic emissions (AE), which is clearly explained, and it performs a theoretical analysis to improve the damage model. The third contribution, by Davy et al, follows this line of research on rock failures, and it presents the flow models that are appropriate for explaining multiscale fracture networks. In basis on the equivalent permeability as well as other flow properties, the authors propose three main length scales. The sixth contribution, by Zvelebil et al, is written by a pluridisciplinary team, with the aim of showing the importance of numerical and graphical methods for improving the rock fall risk assessment and early warnings. Between the advantages of the proposed methods the distinction between intrinsic dynamics and climatically driven slope activity is an important one. Between the methodological contributions, the tenth contribution, by Kidson et al, is the only devoted to flood frequency analysis. In the paper a simple Power Law (PL) model is compared with conventional distributions for the prediction of outlier flood events. After the analysis of peak annual instantaneous discharges for 50 US rivers, authors conclude that PL model is a promising alternative to consider both outlier and the bulk of floods within the same framework, and its better suitability for managing extreme floods. The book ends with a methodological paper written by Millington et al, where a quantification of wildfire regimes is presented. Authors confront statistical wildfire frequency-area models suggested by the CA with empirical data from different parts of the world.

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The six remaining papers are mainly focused on cases analysis in Italy and Greece, although their methodological contributions are also important. Paparo et al, monitored crustal stress by AE, which give an indication of whether a physical system is subject to stress. Taking into account that AE signals are indicators of the fatigue state of the crustal structures constituting the AE source, the authors apply fractal analysis to AE time series, particularly to several cases from Italy. The increased high/low frequency AE activity some months/weeks before a large earthquake suggests using it for assessing the time evolution of seismic activity. The contribution of Poscolieri et al is also focused on crustal stress and seismic activity, but, in this case, it introduces the application of different observational techniques over the Ionian Archipelago. Besides the AE measurement the authors apply satellite-based techniques, like Differential Interferometric Synthetic Aperture Radar (DInSAR) and Differential Global Position System (DGPS). The soil exhalation technique and a suitable analysis of the DEM of the Island complete the study. In the seventh contribution, Telesca and his colleagues follow the analysis on seismic hazard in Italy. They study the multifractal variability in the time dynamics of geoelectrical data by means of Multifractal Detrended Fluctuation Analysis (MF-DFA) and propose to apply it for better characterizing the time dynamics of earthquakes. The eighth paper, by Turcotte et al, is focused on landslides in Italy. The authors examine the applicability of a general landslide inverse-gamma function over an inventory of 165 landslides triggered by heavy rainfall in the region of Todi, Italy, and show its good agreement. This general distribution was established using 24 000 landslide events triggered by different causes and recorded in USA, Italy and Guatemala. The scaling properties of the dimensional and spatial characteristics of fault and fractures in carbonate rocks in the central Apennines, Italy, is analysed in the ninth contribution, by Marchegiani et al. The authors elaborate a three-dimensional discrete fault and fracture model to evaluate the transport and storage properties and assess the degree of risk related to the exploitation and management of geofluids hosted in carbonate rock volumes. The central Apennines, Italy, is also the region selected by Cello et al to integrate fault data with earthquake information to derive a relation between the magnitude of the strongest historical earthquake and the fractal dimension of active fault patterns. This integration represents a good low-cost methodology for predicting earthquake magnitudes in this region.

It is a hardback book printed with high quality and clearly illustrations. The price is not too high in comparison with the book interest. It constitutes a very good reference about the present current research on fractal analysis as applied to natural hazards, which is highly recommended for advanced students and researches.