Preface

The past decades demonstrate a spectacular increase of public interest in the problems of safety and reduction of losses from natural and manmade disasters. The study of disaster statistics and disaster occurrence is a complicated interdisciplinary field involving an intimate interplay of new theoretical results from several branches of mathematics, physics, and computer science. Recent progress in systems of remote sensing, in financial and social measurements, and in data collecting gives us a possibility to compile data sets suitable for statistical analysis of disaster damages. The accumulation of factual material relating to various kinds of natural disasters and the use of advanced recording techniques have expanded possibilities for the analysis of empirical distributions of disaster characteristics. This book summarizes recent achievements in the field of statistical analysis of disaster damages. These approaches largely rely on fundamental results of the theory of extreme values (Embrechts et al. 1997; Gumbel 1958; Pisarenko and Rodkin 2010). One should mark the appearance of theoretical and practical tools for effective studies of natural disasters with the associated practical measures taken to reduce the losses. The combination of all the above-mentioned factors results in a considerable progress in natural disaster research. The main focus is on the occurrence of disasters that can be described by distributions with heavy tails. A short overview of properties of heavy-tailed distributions is offered. The relation between the maximum event and the total sum is studied; in the case of heavy-tailed distributions this relation is unusual: the single maximum event can dominate the total sum. This book contains several recent results in the statistical analysis of rare large events. We analyze the size distribution of arbitrary nature in the uppermost range of extremely rare events using a recently developed method (Pisarenko and Rodkin 2010, 2013). One of the most important results of this study is the conclusion about instability of the "maximum possible size" parameter, this parameter is frequently used in seismic risk assessment and in other similar problems. We suggest an alternative robust way to parameterize the tail of the size distribution by means of a robust and stable characteristic—the quantiles $Q_q(\tau)$ of maximum size (e.g., earthquake energy, ground acceleration caused by earthquake, victims and economic losses from natural catastrophes, etc.) that will occur in a prescribed time interval τ. We illustrate our theoretical conclusions by applying the described technique to different natural disasters. The comparative study of losses from earthquakes, floods, tornsdoes and hurricanes is presented. The losses of different types are analyzed: fatalities, number of affected people, overall economic losses. We also emphasize that the methods used here to parameterize the distribution's tail are quite general and are applicable besides the assessment of natural disaster hazards to all the cases where the contribution of rare large events is to be estimated.

The book presents an original approach in the field of disaster statistics recently developed in (Embrechts et al. 1997; Gumbel 1958; Pisarenko and Rodkin 2010). We analyze empirical data related to several types of natural disasters: earthquakes, floods, tornsdoes and hurricanes. The mode of occurrence and statistics of losses from such disasters are considered in detail.

This book aims primarily at specialists in the field of seismology and seismic risk, and could also be useful for specialists in other kinds of natural and manmade disasters. The main statistical results are derived with a mathematical rigor and are presented here in a form that also makes them accessible to readers with no special mathematical background. We hope that this monograph will also be useful for employees of regional and national administrations as well as for a broad class of readers interested in the problems of natural disasters and their impact on the society.

This book has the following structure. Chapter 1, the *Heavy-Tailed Distributions and Their Properties* provides a general overview of heavy-tailed distributions and their properties. In Chap. 2, *The Stable Approach to the Risk Assessment: Estimation of Quantiles of Maximum Event* we describe the specific properties of heavy-tailed distributions and the stable approach to the risk assessment based on the estimation of quantiles of maximum event. We analyze among others the problem of non-stationarity of natural processes (Sect. 2.2) which is important in numerous applications. Several statistical tools are suggested for dealing with this problem. In Sect. 2.4, we adopt our method to the format of aggregated annual data. Chapter 3 is devoted to the statistical analysis of real catalogs of natural disasters: earthquakes, floods, tornadoes, and hurricanes. The quantiles $Q_q(\tau)$ are estimated for each of these catalogs. Finally, in Chap. 4 we discuss the obtained results and give a comparative overview of the analyzed catalogs.

Moscow, June 2013

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http://www.springer.com/978-3-319-01453-1

Statistical Analysis of Natural Disasters and Related Losses
Pisarenko, V.F.; Rodkin, M.V.
2014, XI, 81 p. 84 illus., Softcover
ISBN: 978-3-319-01453-1