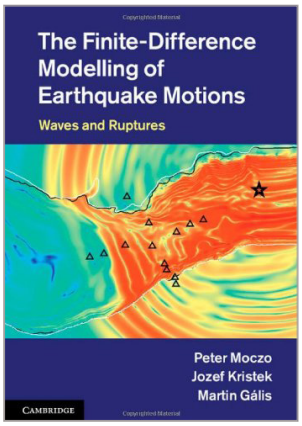
Book review: The Finite-Difference Modelling of Earthquake Motions

Waves and Ruptures



By P. Moczo, J. Kristek, M. Gális

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Numerical modelling plays a major role in many modern scientific branches. Accurate methods combined with detailed models give the possibility to scientists to test their hypotheses. In seismology, the need of sophisticated wave propagation tools started to grow a while ago to narrow the gap between observation and theory. Despite all the approximate methods already available at the time, seismologists started to generate synthetic seismograms extensively by using numerical methods in the seventies. Synthetic waveforms, in contrast with real waveforms recorded by seismometers, are generated on Earth models providing a suitable method to test scientists' predictions. Soon, numerical methods found their way to a wide range of topics from local to global seismology and the new methods started to emerge in order to enhance the modelling accuracy and efficiency.

Among all the numerical methods, maybe the Finite Difference Method (FDM) is the most convenient one to start with due to its simple approach: taking differences from the neighboring points. Albeit simple, there are many challenges arising to adapt this method for different applications such as earthquake ground motion.

The Finite-Difference Modelling of Earthquake Motions, Waves and Ruptures, by Peter Mocza, Jozef Kristek and Martin Gális, is the first book that provides seismologists with a comprehensive introduction to FDM by explaining the method and its applications in earthquake motion. Its main target audiences are academic researchers and graduate students in seismology and geophysics who want to get familiar with numerical seismological techniques. Yet, it is a good reference for those who are familiar with the method but want to learn the details in applying numerical methods to real problems.

The eminent board of authors has a long history in developing and applying Finite-Difference (FD) and hybrid Finite-Difference-Finite-Element methods in seismology. It is clear that a good effort was put into collecting some of their major contributions in the book, which resulted in well written chapters with informative figures. It covers the basics required to understand the method combined with detailed derivations of the equations and advanced examples. Maybe one of the main features of the book is its systematic sectioning, making it easy for the reader to refer to the desired section.

In Part I, the reader gets familiar with the governing equations, the equation of motion and the constitutive law of different media, in the forms usable for FD schemes with an overview over different initial/boundary conditions. These are followed by detailed explanations and formulations of rheological models of a continuum media. The chapter finishes with a comprehensive description on earthquake sources.

The numerical part of the book matures in Part II. After an overview on different numerical methods in solving seismological equations, the authors introduce FDM and explain the basic properties of this method. This consists of spatial FD grids, derivation of the equations and time schemes. An instructive section in this chapter is the application of the FD to the 1D problem, avoiding any complications introduced by three-dimensional domains. However, this has been treated later in this part by explaining the method in 3D media. In all these sections, special attention is given to the accuracy, error analysis and stability of the method as well.

The book goes one step further than pure FDM, and it explains the Finite Element (FE) method, in which the boundary conditions at the free surface can be more easily incorporated. Afterwards, the authors explain a method that combines the advantages of FE and FD in the form of a hybrid FD–FE method.

In the last part, the method is applied to a realistic scenario: modelling of earthquake motion in the Mygdonian basin. This chapter gives a good overview on verification and validation to evaluate the accuracy and reliability of numerical methods in a real example.

One of the remarkable aspects of this book is its usability for a wide range of audience. It has a smooth approach in developing and explaining the required ingredients to introduce and apply the method. In each section, a list of references is provided for further reading in the topic. It covers a variety of challenges that seismologists encounter in using and choosing the convenient forward modelling codes for their applications. Moreover, the book tries to cover lots of topics scattered in different research articles in one book and explains them in a concise way. This is indeed an advantage; however, in some sections, the details can go beyond the patience of non-experienced readers. This can be easily avoided by carefully

selecting the relevant and more general sections for those who do not want to go through all the details.

All in all, The Finite-Difference Modelling of Earthquake Motions, Waves and Ruptures is an excellent book for starting, as well as broadening the knowledge, in numerical seismological techniques. It covers not only the main aspects of computational methods, and in particular FDM, but also familiarises the readers with the applications of the method for more advanced seismological problems.

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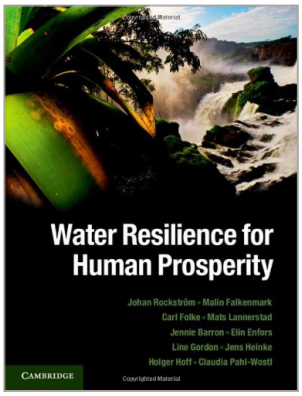
Book review: Water Resilience for Human Prosperity



By J. Rockström, M. Falkenmark, C. Folke, M. Lannerstad, J. Barron, E. Enfors, L. Gordon, J. Heinke, H. Hoff, C. Pahl-Wostl

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The concept of ecological resilience – persistence of a system through change – was introduced by the Canadian ecologist C.S. Holling in 1973. Now, over 40 years later, Water Resilience for Human Prosperity sets an ambitious goal by tackling the world's key resource in the spotlight of global change. While the book's title suggests a focus on the resilience of water resources, Rockström et al. clarify that it rather deals with the role of water in sustainable development. Thus, it addresses students, researchers, planners and decision makers; in short: everyone playing a direct or indirect role on the Earth's ecological path for the future. However, it should be said that it is more of a well-rounded textbook than a how-to guide if you are in an executive position.

The book, written by Sweden- and Germany-based researchers, is separated into nine chapters and includes up-to-date scientific references and excellent figures. The examples are manifold and relevant for practical applications: for instance, two invited authors analyse and compare the socio-economic consequences of groundwater extraction in the plains of China and North America. A summary closes every chapter and key terms are defined in a glossary. The global-level maps and graphs provide the reader with a detailed impression of where our water and sustainability problems are located. All this said, Water Resilience for Human Prosperity is a densely written volume that comes along a bit theoretical at times, but is generally tangible for the reader.

Starting with a thorough look at the role of water in the biosphere, the book then moves to human alterations of the water cycle and the complex socio-economic interrelations connected to them. On the way, it addresses today's urgent issues such as climate change, land conversion and the growth of population which, for themselves, may be worth looking into. Processes are linked from the local to the global scale and across the gap between ecology and economy. Finally, the volume offers approaches on how the resulting new dynamics can be managed.

A thematic focus is put on food production. The reason for this is a required 70% increase in production to feed the expected population in 2050, combined with the fact that water is the limiting resource for food production in many strong-growing countries. Additionally, the authors devote an extra chapter to the savannah zone, as it represents 30% of land area and population and has high agro-hydrological potential, which suggests the possibility of more than doubling the yield from farming in the future.

What I appreciated most about the book is that it does not simply collect, point out and link sustainability issues around the world, but names and explains strategies to increase water and food resilience, such as a functioning global food trade, the increase of food stocks and diet change towards a greater share of plant-based calorie intake. It is, however, realistic by admitting the challenges and limits of the various approaches.

Overall, this isn't a book you would bring on a holiday; reading Water Resilience for Human Prosperity is hard but fruitful work given how informative the volume is. If you haven't worked on water, it's a great interdisciplinary and contemporary introduction to it. If you're a hydrologist, you may still find it a valuable read, because it comprises the global, socio-economic and complex perspective of today's changing world.

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BACK TO CONTENTS