

Preface to the 4th Edition

The book *MATLAB Recipes for Earth Sciences* is designed to help undergraduate and postgraduate students, doctoral students, post-doctoral researchers, and professionals find quick solutions for common data analysis problems in earth sciences. It provides a minimal amount of theoretical background and demonstrates the application of all described methods through the use of examples. The MATLAB software is used since it not only provides numerous ready-to-use algorithms for most methods of data analysis but also allows the existing routines to be modified and expanded, or new software to be developed. The book contains MATLAB scripts, or *M-files*, that can be used to solve typical problems in earth sciences by simple statistics, time-series analysis, geostatistics, and image processing, and also demonstrates the application of selected advanced techniques of data analysis such as nonlinear time-series analysis, adaptive filtering, bootstrapping, and terrain analysis. The book's supplementary electronic material (available online through Springer Extras) includes recipes with all the MATLAB commands featured in the book and the example data. The MATLAB codes can be easily modified for application to the reader's own data and projects.

This revised and updated Fourth Edition includes new sections on creating graphical user interfaces with MATLAB, on hypothesis testing (including the Kolmogorov-Smirnov test, the Mann-Whitney test and the Ansari-Bradley test), on detecting abrupt transitions within time series, on exporting 3D graphics to create interactive documents, on processing LANDSAT and HYPERION satellite images, on shape-based object detection in images, on discriminant analysis, and on multiple linear regression analysis. Many of the pre-existing sections have also been expanded and rewritten, and numerous new examples have been included.

In order to derive the maximum benefit from this book the reader will need to have access to the MATLAB software and be able to execute the recipes while reading the book. The MATLAB recipes display various graphs on the screen that are not shown in the printed book. The tutorial-style book does, however, contain numerous figures making it possible to go through the text without actually running MATLAB on a computer. I have developed the recipes using MATLAB 8 Release R2014b, but most of them will also work with earlier software releases. While undergraduates participating in a course on data analysis might go through the entire book, more experienced readers may choose to refer to only one particular method in order to solve a specific problem. The concept of the book and the contents of its chapters

are therefore outlined below, in order to make it easier to use for readers with a variety of different requirements.

- *Chapter 1* – This chapter introduces some fundamental concepts of samples and populations. It also links the various types of data, and questions to be answered from the data, to the methods described in the succeeding chapters.
- *Chapter 2* – A tutorial-style introduction to MATLAB designed for earth scientists. Readers already familiar with the software are advised to proceed directly to the succeeding chapters. The Fourth Edition now includes new sections on matrix manipulation, control flow, and creating graphical user interfaces. Many passages in the older sections have been expanded and rewritten.
- *Chapters 3 and 4* – Fundamentals in univariate and bivariate statistics. These two chapters contain basic concepts in statistics and also introduce advanced topics such as resampling schemes and cross validation. Readers who are already familiar with basic statistics might want to skip these chapters. The Fourth Edition now also includes an introduction to hypothesis testing as well as new sections on the Kolmogorov-Smirnov test, the Mann-Whitney test, and the Ansari-Bradley test. Furthermore, the section on correlation coefficients has been expanded to include introductions to Spearman's correlation coefficient and Kendall's correlation coefficient.
- *Chapters 5 and 6* – Readers who wish to work with time series are recommended to read both of these chapters. Time-series analysis and signal processing are closely linked. A good knowledge of statistics is required to work successfully with these methods. These two chapters are independent of the preceding chapters. The Fourth Edition now also includes a section on detecting abrupt transitions within time series.
- *Chapters 7 and 8* – I recommend reading through both of these chapters since the processing methods used for spatial data and for images have much in common. Moreover, spatial data and images are often combined in earth sciences, for instance when projecting satellite images onto digital elevation models. The Fourth Edition now includes new sections on exporting 3D graphs to create interactive documents. The introduction to remote sensing using MATLAB has been expanded and now includes sections on importing, processing and exporting LANDSAT, ASTER and HYPERION satellite images. Chapter 8 now also includes a comprehensive discussion of methods for image enhancement, correction and rectification as well as a new section on shape-based object detection in images.

- *Chapter 9* – Data sets in earth sciences often have many variables and many data points. Multivariate methods are applied to a great variety of large data sets, including satellite imagery. Any reader particularly interested in multivariate methods is advised to read Chapters 3 and 4 before proceeding to this chapter. The Fourth Edition now includes new sections on discriminant analysis and multiple linear regression, and the older sections have been substantially rewritten.
- *Chapter 10* – Methods to analyze circular and spherical data are widely used in earth sciences. Structural geologists measure and analyze the orientation of slickensides (or striae) on a fault plane. The statistical analysis of circular data is also used in paleomagnetic applications. Microstructural investigations include the analysis of grain shapes and quartz c-axis orientations in thin sections.

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Martin H. Trauth

Preface to the Interactive 4th Edition

With this fourth edition the book makes its first appearance as an interactive ebook. This format allows the reader to follow the contents in much the same way as they are presented in the courses that I teach at the University of Potsdam and elsewhere. During such courses the participants interact with the various tools by changing the input parameters of the algorithms and exploring the subsequent modifications introduced to the graphics. The spectral analysis of time series is demonstrated not only by examining graphics but also by listening to audio examples of signals and noise. Using MATLAB to visualize three-dimensional digital terrain models that can be rotated interactively helps to understand complex topography much better than two dimensional graphics.

This ebook allows the reader to interact with the book in a very similar manner. It comes in two different formats, with the first being for Apple iPads and Macs (in the form of an *.ibooks* file created with Apple's iBooks Author software) and the second being for other platforms (as a PDF file created with Adobe InDesign). The ebook has been designed to be read in landscape mode; it includes movies, galleries, audios and interactive 3D displays, as well as reviews at the end of each chapter. The *movies* demonstrate the use of graphical user interface tools; they also help to explore the effect that changing input parameters has on the output of a function and to visualize mathematical operations. *Galleries* are generally used to present a series of linked graphics, such as those displaying the various measures of the dispersion and shape of a distribution. *Audios* are used to provide a striking representation of signals and noise, as well as the effect of filters. *Interactive 3D displays* allow interactive rotating of digital terrain models and other three-dimensional objects. Each chapter ends with a *Review* (or quiz), which tests the reader's understanding of its content. These interactive media (or widgets) can be explored, observed, or listened to (on Macs) using a multi-touch trackpad or a mouse, or (on iPads) using your finger(s), by clicking the Play button (to watch movies and to listen to audios), by clicking the arrows or swiping left or right (to navigate through a gallery), or by clicking and dragging a 3D object to rotate it. Movies, galleries and 3D objects can be zoomed to full screen by toggling the full-screen mode in the lower right corner (with movies), or by simply clicking on the image (with galleries and 3D objects).

The interactive ebook for other platforms comes as a *.pdf* file, which can be accessed with the free Adobe Reader software. The reader of the PDF version of the book receives a complete package of files that includes the

actual ebook as well as a series of directories containing the interactive objects, the recipes with all the MATLAB commands featured in the book and the example data. It is important to note that the specified directory tree, especially the names of the directories, should not be changed. The layout



of the *.pdf* file is identical to that of the printed book with icons outside the type area that refer to the interactive objects. The interactive objects are stored outside the PDF file and can be accessed from the *MRES4-Index.html* file that can be viewed in a web browser. The PDF version of the ebook contains all interactive objects included in the ebook for iPads and Macs, except for the reviews. The

interactive PDF version was planned as an ebook with embedded interactive objects such as movies, galleries, audios and reviews. During the production process, however, it soon became clear that it is not yet possible to offer such a product that is compatible with all platforms.

The first edition of *MATLAB Recipes of Earth Sciences*, which came out in 2006, contained many small, and some (unfortunately) not so small, errors. These errors made it necessary to produce an errata file that was made available for download on my webpage. The ebook now allows the contents to be kept up-to-date through regular updates that is possible for the printed book. It is thus a living book that thrives on the comments of its readers, which I expect to receive in due course!

I hope that you enjoy using the animated objects while reading the interactive ebook! Comments, corrections and suggestions are very welcome.

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