Book Review

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Analysis of the gravity field, direct and inverse problems, by Fernando Sanso and Daniele Sampietro published by Birkhäuser 2022

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1 Summary

This new book deals with, as its titles says, the analysis and process of gravity field of the Earth. The book is mathematically oriented, and the authors have explained how Mathematics is used for local analysis of the gravity field. The basic and required background knowledge, needed for understanding the book, are given in early chapters as well as appendices. They are used for explaining gravity field analysis from measurement surveys, corrections, and processes to direct and inverse problems in exploration Geophysics with interesting exercises, numerical and real examples.

2 Remarks

After reading the book, this reader summarises some general and specific remarks to it.

3 Presentation and text

The book is indeed well-written, and text is straightforward to understand, even if at the first glance it is like a book in Mathematics containing theorems, propositions, lemmas, and corollaries. This style of writing may make the book slightly difficult to read, but if the readers have knowledge about the calculus should be able to understand the book. The authors have mentioned that this book is accessible to mathematicians and geophysicists, and they have tried to keep mathematical rigor. If the readers have enough knowledge in Mathematical Physics and Statistics, they should have no problem. However, it is recommended that the readers start from the first chapter and Appendix A to be familiarised with the style of the book. One good point of the book is the outline written as an introduction to each chapter, clarifying its goals in a simple way.

4 Exercises and Matlab codes

One of the strongest points of this book is the designed exercises with their solutions at the end of each chapter. These exercises make the book suitable as a good reference in academia for teaching students in Mathematics, Physics, Geophysics, and Geodesy. However, since good background in Mathematical Physics and Statistics is needed, the book is more suitable for higher education students unless enough knowledge in Mathematical Physics is provided to the students. Jacob and Smilde's (2009) book "gravity interpretation," containing similar contents, is simpler and more suitable for geoscience students. Some simple Matlab codes are provided at the end of some chapters, which are helpful for the readers to see how to code the complicated formulae. It contains one code for upward continuation using the Poisson integral (Heiskanen and Moritz 1967) and one for inversion using the Parker–Oldenberg method (e.g. Gómez-Ortiz and Agarwal 2005) for Moho recovery. A code for teaching how to apply Fast Fourier Transform for evaluation and inversion of a 2D simple convolution integral in Chapter 3 would have been extremely helpful.

5 Some specific contents

As the authors mentioned, the book has focus on the gravity field analysis at local level rather than global,

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unlike what Eshagh (2020) did with a pure global perspective. This is interesting and important, especially in gravity surveys, processing, exploration Geophysics, prospecting applications, and recovering high frequencies of geoid from the topographic masses. As the book shows, for large areas the spherical harmonic series need to be applied.

The necessary corrections to the gravimetric survey are explained rather well, particularly, the least-squares adjustment of the gravity networks is presented with excellent numerical examples. However, the gravimeter and gradiometer instruments could have been explained more (see Torge 1989).

Classification of geological regimes using the Nettleton method, discussed in Section 6.3, is interesting and practical for clustering the data. Residual terrain correction is presented mathematically well, and the book shows how many approximations should be taken so that the involved integrals become suitable for applying the Fourier transform. Such approximations are good when the slope of topographic masses is less than 45 degrees, making the method more suitable for areas not with a rough topography. Inversion of the real airborne gravimetry data in Chapter 9 was extremely interesting particularly using the Bayesian inversion method for the mass anomalies having complicated forms. Even the special truncation error of this method is smaller than that inversion by the Fourier method according to Figure 9.10. The main drawback is the slow performance of the method, which limits its practicality.

The gridding method using the least-squares collocation is discussed well in Section 6.6, but the readers are advised to read Appendix B to understand the concept better. We should admit that Appendix B is rather challenging if the readers do not have good background in Mathematical Statistics. The simple Matlab code provided for this purpose is useful.

Determination of anomalous mass, its barycentre depth and minimum depth, as well as Parker's method for interface detection, which are presented in the beginning of Chapter 7 is extremely useful for the exploration geophysicists. Chapter 8, which deals with mathematical characteristics of inverse gravity problem, is purely theoretical and could have been presented simpler. For example, the discussion about the Tikhonov regularisation is explained mathematically in continuous domain. It is theoretically beautiful, but practically the matrix approach, presented in Appendix C, is more useful.

The use of the Fourier method (see also Jekeil's 2017 book) for analysing different aspects of gravity is indeed interesting through the book and rather unique. Their focus on local extent areas and presenting different methods and mathematical derivations for local analysis of gravity data are complete and distinctive.

6 Conclusion

Generally, this book is theoretical and advanced, suitable as a reference in academia for students of higher education working on small extent exploration Geophysics by gravity data. For understanding the theory and analysis of the Earth's gravity field, strong backgrounds in Mathematical Physics and Statistics are required, and the readers are supposed to be good in them, even if the book provides the required knowledge. Such readers can follow the book and learn what the book says about all interesting and useful subjects about gravity field analysis. This is the main limiting issue of the target audiences of the book. For this reviewer, reading this book and following its mathematical explanations and derivations are indeed enjoying although some parts are challenging.

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