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Enhanced Surface Imaging of Crustal Deformation

Obtaining Tectonic Force Fields Using GPS Data

Springer

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We dedicate the book to the late John Beavan. John provided the dataset used in Chap. 5, which together with Chap. 4 is built around our initial, 1-dimensional analyses before embarking on the full 2-dimensional methodology. He knew we were making good progress, but passed away due to cancer in November 2012, two months into the project, just when John Haines returned from Austin to show him the first results. Though he never saw those results, we like to think he could imagine what they were like, and John Haines had a quiet time of gratitude and respect alone with him after the end. His contribution to geodetic research in New Zealand was immense.

Preface

Within these pages, you will find a description and application examples of a unique new technique for resolving and interpreting subsurface movements of the Earth in terms of surface deformation observations. The result is the highest possible resolution surface image of the ongoing subsurface deformation, without prescribing the nature or location of this deformation. As such, it represents a big step from other current methodologies. This work was prompted by the devastating earthquake sequence in Christchurch in 2010–2011 which occurred on previously unknown faults, some directly underneath the city of Christchurch. In response, the New Zealand Government through the Natural Hazards Research Platform funded the authors of this book to join together and develop a new methodology to enable investigation of what other hidden sources of deformation and potential natural hazards lie beneath the country. This project, as any applied science project, was concerned with coming up with a pragmatic solution, in an integrated and practical package. The resulting methodology, described here, does exactly that but goes beyond and provides a tool to guide future detailed studies elsewhere in the world.

We anticipate that the geodetic evaluation and interpretation method described here will be widely useful within the geodetic community, and this book is primarily intended for those who wish to make use of the technique. As such, one of our primary goals was to provide a thorough exposition of the methodology so that readers would be able to duplicate our results. In Chap. 1, we first provide the necessary background describing previous methods and explain why this method is a significant improvement. In Chap. 2, we introduce the new physical quantities we extract from geodetic data. These are surface quantities in the force balance equations at the Earth's surface: Our methodology is built around surface equations, which are 2-dimensional in their full form. In Chap. 3, we provide a detailed description of the method, which should be very useful for readers wishing to use the technique themselves. Chapters 4–6 all provide examples of applying the technique to real and simulated geodetic data. In Chap. 4, we examine some characteristics of the 1-dimensional forward problem with respect to simple synthetic faulting examples, as well as comparing synthetic inversion results with those of a previous method. In Chap. 5, we apply the 1-dimensional version of the

method to eight profiles in the South Island of New Zealand, highlighting the ability of our method to resolve features such as fault locking depth and investigating the dependence of resolution on station spacing. In Chap. 6, we examine 2-dimensional synthetic examples to demonstrate the ability of our technique to highlight active deformation sources and to provide robust inversion results for reasonable distributions of observation points. Finally, in Chap. 7, we summarize the technique and its applications and discuss some possible adaptations and extensions.

A considerable amount of work has gone into this book, and we sincerely hope that it will be interesting and useful to you.

Sincerely,
A. John Haines
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Contents