

Preface

The present book collects the lecture notes of the international Wilhelm und Else Heraeus autumn school ‘Global Gravity Field Modeling from Satellite-to-Satellite Tracking Data,’ held from October 4 to 9, 2015, in Bad Honnef, Germany. The first ideas of the autumn school (the initial plan was a summer school) came up in November 2013 during an internal discussion in Hannover on the requirements for the GRACE/GRACE Follow-On Mock Data Challenge project¹ in the Collaborative Research Center (Sonderforschungsbereich) 1128 ‘Relativistic Geodesy and Gravimetry with Quantum Sensors (geo-Q)’ of Leibniz Universität Hannover.² The idea soon attracted attention, and we received positive feedback from experts of the field.

In a rather short period of application time, we received many applications from around the world and we are pleased for hosting over fifty participants from Germany, USA, Switzerland, Austria, India, China, Iran, Russia, Bulgaria, Netherlands, Poland, Brazil, Luxembourg, Canada, and Sweden.

The main goal of the autumn school was to provide a basis to the interested students and geodesists for analyzing SST data from current and future satellite missions. The emphasis was put on different approaches for the recovery of the Earth’s gravity field. These techniques are the acceleration approach, the energy balance approach, and the classical (variational) approach. In addition, the related subjects of orbit determination and parameter estimation were included.

The school started on Sunday 4 October with an opening talk by Prof. Reiner Rummel about the spherical harmonic analysis and gravity field determination and was followed by a 5-day intensive program. Core topic lectures on each morning

¹<http://www.geoq.uni-hannover.de/mock.html>

²<http://www.geoq.uni-hannover.de>

were complemented by more numerical and practical exercises in the afternoon. The chapters of this book are based on the core topic lectures given on each day as follows:

1. **Parameter Estimation for Satellite Gravity Field Modeling**, by Prof. Jürgen Kusche and Anne Springer, University of Bonn, Germany

This chapter gives first a general overview about Gauss–Markov models and their use in the presence of observation noise. Variance component estimation, regularization, and biased estimation are addressed. Exercises at the end of the chapter give more insight into the applications for gravity field determination from GRACE data.

2. **Precise Orbit Determination**, by Prof. Adrian Jäggi and Dr. Daniel Arnold, University of Bern, Switzerland

Here, the general issues of orbit modeling such as the treatment of tracking data, orbit representation techniques, and the orbit determination problem together with gravity field parameterization are considered. Two exercises for a deeper understanding of orbit determination are added.

3. **The Classical Variational Approach**, by Prof. Srinivas Bettadpour and Christopher McCullough, University of Texas at Austin, USA

The basic principles of the classical approach used by processing centers such as CSR and GFZ are discussed, followed by numerical exercises for more understanding.

4. **The Acceleration Approach**, by Dr. Matthias Weigelt, Institut für Erdmessung, Leibniz Universität Hannover, Hannover, Germany

A comprehensive overview about the acceleration approach including the strengths and drawbacks of this method is provided in this chapter. Approximate and rigorous solutions using this approach are discussed, with the exercises on the numerical aspects.

5. **The Energy Balance Approach**, by Prof. Christopher Jekeli, Ohio State University, USA

This chapter reviews the energy integral for the derivation of potential differences along the satellite orbit and for gravity field determination. Aspects of this approach including the separation of the temporal variations, the rotational potential, kinetic potential, and dissipative forces are described. Similar to other chapters, exercises provide more understanding about the numerical details of the method.

Acknowledgements

We would like to thank all the lecturers for contributing to the autumn school, for providing great lectures and exercises as well as for the fruitful discussions. Their great efforts to provide these lecture notes will certainly make this book as a long-lasting reference in satellite gravimetry. We also thank all attendees of the school who, with their enthusiasm, created a scientific and friendly atmosphere during the school.

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Data and Material for Exercises

All data and programs for the exercises as well as their solutions (if provided) are available at the following online repositories:

www.geoq.uni-hannover.de/autumnschool-data
<http://extras.springer.com>

For Chap. 2, the related files can be downloaded from:

<http://aiuws.unibe.ch/WEHeraeusAS2015/Chapter2-OrbitDetermination.zip>

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