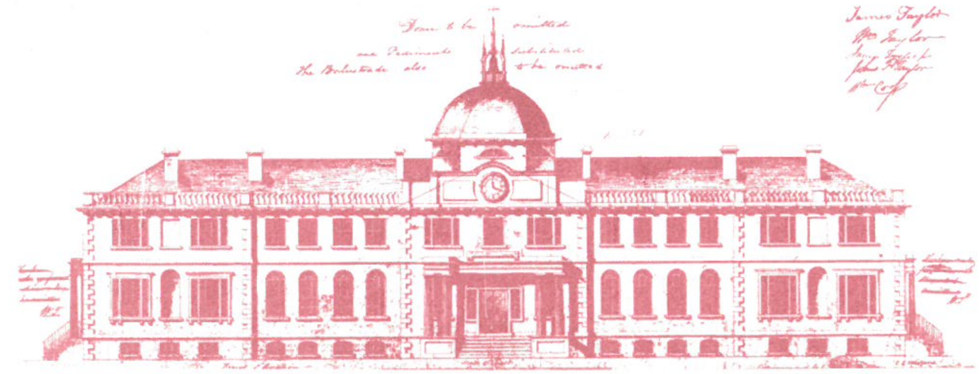
Accuracy of the Classical Height System

Abstract

Measuring the quality of the classical height system through its self-consistency (congruency) is investigated in this dissertation. Measuring the congruency is done by comparing the geoidal heights determined from a gravimetric geoid model with test geoidal heights derived at GNSS/Leveling points. The components of this measurement are computed as accurate as possible, e.g., the Stokes-Helmert approach is used to determine the geoid model, gravimetric and topographic corrections are applied to the spirit leveling observations to derive rigorous orthometric heights at test points, and finally, the geodetic heights are taken from GNSS observations.

Four articles are included in this dissertation, one is discussing a modification to the Stokes-Helmert approach to use the optimal contribution of the Earth gravitational models and the local data. In the second paper, the methodology presented in the first paper is implemented and results are presented in detail for a test area. The third paper is a discussion on the accuracy of the classical height system against Molodensky's system and presents a numerical study to show that the classical system can be computed as accurate as Molodensky's. The last paper presents a methodology to find the most probable solution of the downward continuation of surface gravity to the geoid level using the least-squares technique. The uncertainties of the geoidal heights are estimated using least-square downward continuation and a priori variance matrix of the input gravity data. The total estimation of the uncertainties of the geoidal heights confirms that geoid can be determined with sub-centimetre accuracy in most of the flat areas when, mainly, the effect of topographic mass density is taken into account properly, the most probable solution of downward continuation is used, and the improved satellite-only global gravitational models are merged with local data optimally.



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UNIVERSITY OF NEW BRUNSWICK
SCHOOL OF GRADUATE STUDIES

ORAL EXAMINATION

Ismael Foroughi

IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

Ph.D. Candidate

Ismael Foroughi

Graduate Academic Unit

Geodesy & Geomatics Engineering

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November 14, 2018

2:00 p.m.

Head Hall (Room E-13)

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Examining Board:
Dr. Marcelo Santos (Geodesy & Geomatics Eng.) Supervisor
Dr. Robert Kingdon (Geodesy & Geomatics Eng.)
Dr. James Watmough (Math & Stats)
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Universities attended (with dates & degrees obtained):

2014-2018	PhD candidate, University of New Brunswick
2010-2013	MS in Geodesy & Geomatics, University of Tehran, Iran
2006-2010	BS in Geodesy & Geomatics, University of Tehran, Iran

Selected Publications:

First author refereed journal articles (7)

- **Foroughi, I.**, Vaníček, P., Kingdon, R.W., Goli, M., Sheng, M., Afrasteh, Y., Novak, P., Santos, M. (2018) Sub-centimtre geoid. **Journal of Geodesy** (Accepted and in press for publication).
- **Foroughi, I.**, Safari, A., Novak, P., Santos, M. (2018) Application of radial basis functions in height datum unification. **Geosciences** 8(10), 369.
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- **Foroughi, I.***, Vaníček, P., Novak, P., Kingdon, R., Sheng, M., Santos, M. (2017) Optimal combination of satellite and terrestrial gravity data for regional geoid determination using Stokes-Helmert's method, the Auvergne test case. **IAG Symposia series**, Thessaloniki, Greece.
- **Foroughi, I.**, Tenzer, R. (2017) Comparison of different methods for estimating the geoid-to-quasigeoid separation. **Geophysical Journal International**, 210 (2) pp 1001-1020.
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- **Foroughi, I.**, Tenzer, R., Novak, P., Hirt, C., Pitonak, M. (2018) Spatial and spectral analysis of gravity field quantities of telluric planets and Moon. **Survey in Geophysics** (Submitted and under review for publication).

Second author refereed journal articles (9)

- Goli, M., **Foroughi, I.**, Novak, P. (2018) The effect of the noise, spatial distribution, and interpolation of ground gravity data on uncertainties of estimated geoidal heights. **Studia Geophysica et geodetica** (accepted for publication).
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- Tenzer, R., **Foroughi, I.** (2018) On the applicability of Molodenkij's concept of heights in planetary sciences. **Geosciences** 8 (7) pp 239.
- Tenzer, R., **Foroughi, I.**, Sjoberg, L.E., Bagherbandi, M., Hirt, C., Pitonak, M. (2018) Definition of Physical Height Systems for Telluric Planets and Moons. **Survey in Geophysics** 39 (3) pp 313-335.
- Tenzer, R., **Foroughi, I.** (2018) Effect of the mean dynamic topography on the geoid-to-quasigeoid separation offshore. **Marine Geodesy**, 41 (4) pp 368-381.

Several other Refereed Journal Articles