Recovery of the Egyptian gravity field using new satellite missions

A Thesis
Submitted to the Faculty of Engineering
Ain Shams University for the Fulfillment
of the Requirement of M. Sc. Degree
In Civil Engineering

Prepared by

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(SURVEYING)

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DEDICATION

This work took years from my life. I wish to dedicate it to who suffered to educate, prepare and help me to be as I am,

TO MY MOTHER AND THE SOUL OF MY FATHER

I wish to dedicate my thesis

TO MY SISTERS

for their encouragement and help to complete this work.

I would like to dedicate my thesis to our Egyptian revolution martyrs who fought so dedicatedly for their freedom. May their souls rest in perfect peace

Statement

This dissertation is submitted to Ain Shams University, Faculty of Engineering for the degree of M. Sc. in Civil Engineering.

The work included in this thesis was carried out by the author in the department of Public Works, Faculty of Engineering, Ain Shams University, from 2008 to 2012.

No part of the thesis has been submitted for a degree or a qualification at any other University or Institution.

The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

Date: …. / …. /2013

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Abstract

The need for geo-potential models have increased dramatically in recent decades. It is known that, these geo-potential models are computed using all kinds of available relevant geodetic and gravimetric data all over the world, and the production of models using these sparse data with reasonable accuracy is a difficult task that needs great care.

The rapid developments in space sciences lead to numerous new applications in oceanography, geophysics, geology in general and geodesy in specific. The presence of the new satellite missions provide a homogeneous and near-complete global coverage of gravity field information, which can be improved for local areas using terrestrial gravity data. Consequently with these new satellite mission (CHAMP, GRACE and GOCE), numerous global geo-potential models have been released in the last decade. In addition, the primary objective of the GRACE mission is the determination of time variable changes in the Earth's gravity field caused by geophysical and climatologically driven processes, time series of global gravity models in terms of spherical harmonics are estimated from monthly batches of GRACE data, thus representing the evolution of the changing gravity field at a monthly resolution. All these new models can be an assist to the Egyptian gravity field and the corresponding Egyptian geophysical and engineering applications for both time variable and invariable applications.

Against these new geo-potential models, it is important to evaluate the reliability of EGM96 model, which is one of the extensively used models in Egypt in the last fifteen years, for the Egyptian usage. Also, it is important to evaluate the possibility of using these GRACE time variable models as a new technique for monitoring of the water volume in the River Nile.

The proposed research thesis tests the effectiveness of using newly produced geo-potential (space only and combined) models, which released from 2008 to 2010, for the Egyptian gravity field. Also, the corresponding time variable changes at the Nile basin benefiting from the monthly geo-potential models created from GRACE data were tested in the period from 2005 until 2010. Three satellites will be used in this research study (CHAMP, GRACE, and GOCE) for the recovery of the Egyptian gravity field; and GRACE will be used for the time variable monitoring of the Nile basin.

The thesis analysis is divided into three parts. The first one is a comparison between EGM96 and new satellite mission Geo-potential model at both global and local basis. The second is the detection of the most suitable new geo-potential model for observed terrestrial data at the Egyptian territory. The third is the evaluation of the time variable models produced from GRACE over the Nile basin.

The first part of the research thesis checks the compatibility between the new satellite missions and EGM96 model. A statistical comparison between the gravity field parameters derived from the newly produced global geo-potential models and those derived from EGM96 model, which is the most recently used model in Egypt, will be done. The obtained results indicated that the combined models, which contain terrestrial data and satellite data, match with EGM96 model more than the satellite-only model; and hence, the data from the new satellite missions does not match well with the gravity field from EGM96 model and that is because the EGM96 misses the homogenous global coverage that is one of the main advantage of the new satellite missions based geo-potential models.

In the second part, the most suitable geo-potential model that matches with the local observed data in the Egyptian territory is determined. A statistical comparison between gravity field parameters derived from different new global geo-potential models, including those based on the new satellite missions against the EGM96 model, and terrestrial gravity observed data over the Egyptian territory is done. The obtained results indicated that EGM08 model is the best geo-potential model approximating the gravity in Egypt.

In the third part, changes of the terrestrial water storage variations calculated from the GRACE monthly time variable models was tested over the Nile Basin. A statistical comparison between the terrestrial water storage variations from GRACE and those from global hydrological model (GLDAS) was done over the Nile basin. The results obtained was clearly showing that GRACE time variable models can be used in the southern part of the Nile basin with accuracy about 80%, and it is not recommended to use these time variable models in the northern part of this basin, because of the low resolution of these models compared to the Nile basin area coverage.

Acknowledgement

One of the prettiest moments of my graduate studies was when I was completing the cover page of this thesis. It was a wonderful feeling of finishing another important period of my life. A period that was full of happiness and sadness, relaxation and anger, satisfaction and frustration. A period from which I gained so much knowledge; not only scientific knowledge, but that kind of knowledge that is so hard to learn from science; it is the knowledge of how to go on in life and how to share it with those you love, friends, colleagues, and people in general.

Having the opportunity to write what I feel, it is time I wrote my acknowledgments. First, I want to thank God for all the things He has blessed and is still blessing me with, without which I would not be able to pursue knowledge, or even life.

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