Journal of African Earth Sciences xxx (xxxx) 104202

Contents lists available at ScienceDirect

Journal of African Earth Sciences

journal homepage: www.elsevier.com/locate/jafrearsci

An assessment of spatial methods for merging terrestrial with GGM-derived gravity anomaly data

Joseph O. Odumosu[a,*], Victor C. Nnam[b], Ifeanyi J Nwadialor[a]

[a] *Department of Surveying and Geoinformatics, Federal University of Technology, Minna, Nigeria*
[b] *Department of Surveying and Geoinformatics, Enugu State University of Science and Technology, Enugu, Nigeria*

ARTICLE INFO

Keywords:
Free air anomalies
Least squares collocation
Global geopotential models
Omission error
Commission error
Atmospheric correction
Nigeria

ABSTRACT

The practice of merging terrestrial gravity anomalies with Global Geopotential Model (GGM) derived quantities has become popular in geodetic applications. That notwithstanding, GGM-derived gravity anomalies are mostly not consistent with their terrestrial counterparts. This study presents a method for reducing the inconsistencies between both datasets by the application of atmospheric correction, omission and commission errors to GGM-derived data. Furthermore, the study offers a comparison of the padding, kriging and least-squares collocation (LSC) methods for merging terrestrial and GGM-derived gravity anomalies. The three models were assessed by Leave Out (LO) validation method using 15 terrestrial data points that are well distributed across the study area (Nigeria). Three GGM's (EGM96, EGM2008 and SPW 5) were evaluated, and EGM2008 was selected as being optimal within the study area. The EGM2008-derived data were then merged with 1800 terrestrial FA anomaly data covering the area. Results obtained indicate the relevance of applying the atmospheric correction, omission error and commission errors to GGM-derived data before merging them with terrestrial data. Within the test region, the omission error had the largest contribution to the GGM-data inconsistency with values ranging from −72.18 to 43.98mgals. Also, the LSC technique produced the best result for the data merging with a standard deviation of residuals of ±5.77mgals, followed by the padding method with a standard deviation of residuals of ±6.35mgals.

1. Introduction

Several geodetic and geophysical applications require a very accurate and dense network of gravity stations across the Earth surface and particularly within the region wherein such studies are to be conducted. Unfortunately, terrestrial gravity observations have always produced a sparse network of points due to cost of the required field observations (Telford et al., 1990; Torge, 2001) as well as the time required to cover large spatial extents. Consequently, the terrestrial data coverage is often not adequate for most geodetic applications, especially where large spatial extent is involved. On the other hand, satellite geodesy has made it possible to obtain accurate information at regional/global scale about the Earth's gravitational potential through the developments of Global Geopotential Models (GGM). GGM's provide a seamless and complete global overview of the Earth's gravity spectrum (Amos, 2007). A GGM is a mathematical description of the Earth's gravitational field which is achieved by the harmonic expansion of the Earth's gravitational potential based on either terrestrial data, satellite-derived potential coefficients or a combination of both (Rapp and Pavlis, 1990; Pavlis, 2012). However, since the spatial resolution of the GGM is directly related to its maximum degree of expansion, the best spatial resolution recoverable from GGM's is 9.13 km which can be obtained from the EGM2008 (Roman et al., 2010). This implies that neither the GGM's nor the terrestrial observations alone are sufficient for region-wide gravity field modelling whenever high-resolution gravity data is required. For this reason, the recent practice is to merge terrestrial gravity observations with GGM-derived Free Air (FA) anomalies (Klu, 2015; Yahaya and Azzab, 2019). Many methods have been practically utilized by different researchers for performing such data merging with each researcher justifying the choice of the method utilized. This study presents a detailed comparison of the outcome of some data merging methods and as well proposes the use of least squares collocation (LSC) for merging both datasets. Furthermore, this study presents a method for elimination of inconsistencies between terrestrial and GGM-derived FA anomalies prior merging such datasets.

* Corresponding author.,
E-mail address: odumossu4life@yahoo.com (J.O. Odumosu).

https://doi.org/10.1016/j.jafrearsci.2021.104202
Received 25 May 2020; Received in revised form 15 March 2021; Accepted 27 March 2021
1464-343/© 2021