ON THE DETECTABILITY OF SYNTHETIC DISTURBANCES IN FG5 ABSOLUTE GRAVIMETRY DATA USING LOMB-SCARGLE ANALYSIS

Martin Orlob and Alexander Braun
Department of Geosciences, University of Texas at Dallas, Texas, USA

An instrumental or environmental disturbance (signal plus noise) in FG5 absolute gravimetry observations becomes visible by analyzing the residuals, which represent the misfit from the theoretical acceleration parabola. While spectral analysis of FG5 residuals via classical discrete Fourier transform (DFT) is limited by the non-equispaced nature of the FG5 observations, the Lomb-Scargle periodogram can analyze non-equispaced observations and estimate (detect) signals in FG5 residuals. We investigate the detectability of synthetically introduced disturbances in FG5 residuals using Lomb-Scargle periodogram analysis. The sensitivity of the FG5 measurement and adjustment process is a function of disturbance frequency, amplitude, phase, and signal-to-noise ratio (SNR). We conclude that the used drop length and the transfer function of the instrument can significantly alter the estimated gravity values. Further, we establish a sensitivity function called LOFSMAP which depends on the disturbance parameter space of amplitude, frequency, phase and SNR.

Une perturbation attribuable aux instruments ou à l'environnement (signal et bruit) dans les observations du gravimètre absolu FG5 devient visible en analysant les résiduelles, qui représentent les écarts relativement à la parabole d'accélération théorique. Même si l'analyse spectrale des résiduelles du FG5 par la transformée de Fourier discrète (TFD) classique est limitée par la nature inégale de l'espacement des observations par FG5, le périodogramme Lomb-Scargle peut analyser des observations inégalement espacées et estimer (détecter) des signaux dans les résiduelles du FG5. Nous étudions le caractère détectable des perturbations introduites synthétiquement dans les résiduelles du FG5 au moyen de l'analyse du périodogramme Lomb-Scargle. La sensibilité du processus de mesure et d'ajustement du FG5 est fonction de la fréquence, de l'amplitude, de la phase et du rapport signal-bruit (S/B) des perturbations. Nous concluons que la longueur de chute libre utilisée et la fonction de transfert de l'instrument peuvent modifier considérablement les valeurs de gravité estimées. En outre, nous établissons une fonction de sensibilité appelée LOFSMAP, qui dépend de l'espace de paramètre de la perturbation que sont l'amplitude, la fréquence, la phase et le rapport S/B.

Martin Orlob
martin.orlob@alumnimail.utdallas.edu

Alexander Braun
braun@utdallas.edu

1. Introduction

Absolute gravimetry has seen many innovative applications since the development of the FG5 instrument [*Niebauer et al.* 1995]. Its robustness and accuracy was demonstrated in research measuring Newton's gravitational constant [*Schwarz et al.* 1998] and in developing the electronic kilogram using the Watts balance and Planck's constant [*Eichenberger et al*. 2003; *Steiner et al*. 2007]. It found applications in Earth sciences such as the determination of the rate of glacial-isostatic adjustment [*Lambert et al*. 2006], the determination of vertical land motion [*Williams et al*. 2001; *Mazzotti et al*. 2007], and the calibration of relative gravimetry observations [*Francis et al*. 1998]. In all of the aforementioned applications an accurately estimated gravity value is an important factor which ultimately determines the usefulness of the results and interpretation. Uncertainties related to the determination of long-term gravity changes have been assessed by *Francis et al.* [1998] and *van Camp et al*. [2005]. It is evident that the instrument accuracy of 10 - 20 $\left[\frac{nm}{s^2}\right]$ given by the manufacturer [*Niebauer et al*. 1995] is optimistic when considering all environmental signals contributing to the measured time-distance data from the interferometric process involved in the FG5. The accuracy further depends on the frequency of the signal to be detected and all other disturbances, the repetition frequency of the observations, and the type of noise at a particular station [*van Camp et al*. 2005]. The accuracy becomes even more relevant if processes are studied which only change slowly and by small amounts, e.g., vertical crustal motion. The ratio between vertical crustal motion and associated gravity change is