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Comparison of Satellite Altimetric Gravity and Global Geopotential Models with Shipborne Gravity in the Red Sea

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The determination of a high-resolution geoid in off-shore areas mandates integrating heterogeneous gravity data acquired by different sources such as; global geopotential models (GGMs), satellite altimetry, and shipborne gravimetric observations. On the one hand, the former is obtained exploiting satellite missions, e.g. CHAMP, GRACE, and GOCE, which precisely contribute the long-wavelengths signal, while the latter is acquired over a long time and comprises the short-wavelengths gravitation signal. The goal of this research is the production a consistent gravity field over the Red Sea that can be used afterwards for geoid modelling.
Shipborne gravimetry is often affected by several errors, e.g. instrumental errors, navigational errors, incorrect ties to harbour base stations, and the inconsistent use of reference systems. For this reason, the leave-one-out cross-validation and Kriging prediction techniques were chosen to ensure that the measurements are consistent as well as free of gross-errors. A strict confidence level equivalent to 95.4% was decided to filter the shipborne observations, while the cross-validation algorithm was repeatedly executed until the standard deviation of the residuals converged to a value less than 1.5 mGal, which led to flag about 17.7% of the data as potential outliers. A comparison between the shipborne gravity data with DTU13 and SSv23.1 satellite altimetry-derived gravity models is done. The corresponding results revealed that the different altimetry models almost have identical data content if mutually-compared, where the DTU13 gave slightly better results with a mean and standard deviation of -2.40 and 8.71 mGal, respectively.
A statistical comparison has been made between various GGMs and shipborne gravity data. The Spectral Enhancement Method was applied to fill in the existing spectral gap between the GGMs and shipborne data. EGM2008 manifested the best results with residuals characterised with a mean of 1.35 mGal and a standard deviation of 11.11 mGal.
Finally, the Least-Squares Collocation (LSC) was implemented to combine the shipborne gravity data with DTU13 in order to create a unique and consistent gravity field over the Red Sea with no data voids. The combined model was independently tested using a total number of 95 randomly-chosen shipborne gravity stations. The comparison between the validation dataset and DTU13 altimetric anomalies before and after applying the LSC revealed that a significant improvement is gained from the combined model, in which the absolute mean and standard deviation of the differences dropped from -3.60 to -0.39 mGal and from 9.31 to 2.04 mGal, respectively.