UNIVERSITI TEKNOLOGI MARA

GRAVIMETRIC GEOID MODEL DETERMINATION FOR PENINSULAR MALAYSIA USING LEAST SQUARES MODIFICATION OF STOKES

SAIFUL AMAN HJ SULAIMAN

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ABSTRACT

Geoid is vital information in the determination of orthometric height via GNSS levelling. Based on the ellipsoidal height observed by GNSS, the accurate orthometric height can be easily computed by adding precise and accurate geoid model information. This will particularly enable the users to replace the traditional orthometric height determination techniques to become faster and more cost effective. The Peninsular Malaysia Seamless Geoid Model 2014 (PMSGM2014) is the first geoid model computed based on the Least Square Modification of Stokes' (LSMS) approach. In spite of the available land observation gravity data is sparse and not well distributed, however the PMSGM2014 is successfully constructed as accurately as possible. Based on the literature review, the LSMS is the most appropriate approach in determination of geoid model. However, even with a good approach, the accuracy of the geoid model is totally depends on the quality of the data. In this study, development of gravimetric database is the priority because of an accurate data is required in determination of geoid model using LSMS. The procedure for evaluating, selecting, removing blunders, combining and re-gridding the surface gravity anomalies from land observed gravity, marine ship track and Global Geopotential Model (GGM) and Satellite Altimetry model data has been developed. The cleaning and quality control for the gravimetric database was based on the cross validation approach combined with Kriging spatial interpolation method. The limits of Peninsular Malaysia Gravimetric database are Latitudes S 3^0 00' - N 10^0 00' and Longitudes E96^0 00' - E108^0 00'.The gravimetric geoid model for the Peninsular Malaysia was computed based on LSMS with Additive Correction (AC). The geoid model estimation was firstly computed based on the optimal condition modification parameters (M=L=180 degree/order, $\Psi_0=3^0$, and $\sigma_{\Delta g}$=10mGal). Thereafter, the Additive Corrections (Combined Topographic, Downward Continuation, Total Atmospheric and Ellipsoidal Correction) were added to the estimation geoid height to produce accurate gravimetric geoid height called Peninsular Malaysia Seamless Gravimetric Geoid Model 2014 (PMSGM2014$_{GRAV}$). The PMSGM2014$_{GRAV}$ cover the whole of Peninsular Malaysia at 1 x 1 arc minute grid interval with limited to Latitudes N0^0 00' - N7^0 00' and Longitudes E99^0 00' - E105^0 00'. A total number of 70 GNSS levelling points were qualified to assess the accuracy of PMSGM2014$_{GRAV}$. The accuracy of PMSGM2014$_{GRAV}$ is ±0.142m and after removing the systematic effect and fitting the PMSGM2014$_{GRAV}$using means parametric model, the accuracy was increased to ±0.017mand called as PMSGM2014$_{fitted}$. The applications PMSGM2014$_{GRAV}$ and PMSGM2014$_{fitted}$ as vertical datum for deriving GNSS orthometric height were also performed in absolute and relative sense.

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INTRODUCTION

"Indeed, in the creation of the heavens and earth, and the alternation of the night and the day and the (great) ships which sail through the sea with that which benefits people, and what ALLAH has sent down from the heavens of rain, giving life thereby to the earth after its lifelessness and dispersing therein every (kind of) moving creature, and (HIS) directing of the winds and the clouds controlled between the heaven and the earth are sighs for a people who use reason".

Al-Baqara: 2:164

1.1 BACKGROUND OF STUDY

Depth or height is one of the most important elements in determining a three dimensional coordinates system on the surface of the earth. Both of these elements are normally established from a specific reference surface which is assumed to be zero and is called a vertical datum. In general, a vertical datum can be chosen arbitrarily, and it depends on the activities and purposes of the work.

Mean Sea Level (MSL) and Lowest Astronomical Tide (LAT) are two of the most popular vertical data adopted by many countries around the world. For topographical mapping and construction work, normally MSL is used as a datum in the process of determining the height of the Earth's surface. On the other hand, in hydrographical surveys, a vertical datum is always in reference to LAT and it is also called a Chart Datum (CD) for preparing a nautical chart. Both of these data are created based on the tidal observations made at specific locations over certain periods of time (theoretically 18.6 years)(Kaye & Stuckey, 1973).

The determination of a vertical datum using tidal observation methods will create serious problems and not consistent for wide-area applications(Heck & Rummel, 1990; Kasenda, 2009). This is because the water level differs from one location to another depending on the time. It will cause the vertical datum level to not appear seamless between locations(International Federation of Surveyors, 2006).