Determination of Best Fitting Geoid for Enugu State – Gravimetric Approach

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INTRODUCTION

In recent times, the world have witnessed series of Natural. However, these disasters have raised concerns internationally about sustainable development. Disaster recovery projects require sustainable and reliable geodetic infrastructure which should be based on accurately determined geo-reference frames. In Geodetic and Engineering activities, such geodetic surfaces as the Geoid play a key role in height systems due to the direct relationship that exists between it and the direction of water flow; a major reason why the best fitting local/regional Geoid of every country needs to be accurately determined. An attempt has herein been made to determine a best fitting Geoid for Enugu State, Nigeria using the gravimetric method. A total of two hundred and ninety five (295) stations within the study area were used.

OVERVIEW OF STUDY AREA

Located in South Eastern Nigeria geo-political zone, Enugu state covers an approximate area of about 7,161 sq Km and has a population of about 3,267,837 people and density of about 460/km^2 (2006 Census).

Figure 1: Maps showing Nigeria and an extraction of the study area, Enugu State.

METHODOLOGY

- A total of two hundred and ninety five (295) stations within the study area were occupied for gravimetric observation
- Most of the stations are all along accessible roads and tracks.
- A Lacoste and Romberg (G-512) gravimeter was used to measure the gravity values of all the two hundred and ninety five (295) stations.
- The geoidal quantity N, at a specific control point, P was determined using the classical Stokes formulae, the Gravity anomaly data obtained from the gravimetric observations was used in the evaluation using the classical stokes formula in a mat lab program developed for this study.
- A Hi-Target Differential GNSS system was used on a static mode (10secs for 1hr) and post processed for the determination of the positions and ellipsoidal heights of the stations.
- Ten (10) control points whose Orthometric heights are known were used as check for consistency; these points were established by the Office of the Surveyor General of the Federation (OSGOF) by highly accurate spirit levelling.

DATA USED

Some of the required data for this study include:

- Gravity data of gravity controls within the study area, obtained from the National Geological Survey Agency (NGSA), Nigeria. These data include absolute gravity and gravity anomaly of each control station.
- The geodetic coordinates (ϕ, λ, h) of existing Government Control points in the study area. Obtained from office of the surveyor general of the federation (OSGOF).
- The 1:5000 scale topographic map of the study area.
- Parameters of the reference ellipsoid: Angular Unit: Degree (0.017453292); Prime Meridian: Greenwich (0.00000)Φ0; Datum: D_WGS_1984(Minna Datum); Spheroid: WGS_1984; Semimajor Axis: 6378137.0000 b; Semiminor Axis: 6356752.3142451 a; Inverse Flattening: 298.2572235 1/f. Also obtained from OSGOF.

RESULTS

This study was able to achieve results which are shown in this paper. It achieved database of the two hundred and ninety five (295) stations within the study area, their rectangular coordinates, longitude, latitudes, Normal Gravity, Gravity anomaly, Orthometric Heights and Ellipsoidal Heights. Results obtained were compared with the known controls and a relative geoid model with RMSE of discrepancy = 2.5cm. These were integrated to generate the gravimetric geoid model of the study area.

As a result from a part of an on-going research to determining the hybrid of the study area, the resultant information shall be integrated into the process for completion of the research.

ANALYSIS OF RESULTS

The orthometric heights of the known control points and that which was realised from the gravimetric Geoid model were compared. The Standard Deviation is -0.2457m whiles the Root mean square Error (RMSE) is -0.02457m. The results of the statistical analyses show consistency in the results of the study see table 1 below.

CONTROL ID	Model determined Orthometric Heights (m)	Geometric Orthometric Height(m)	Diff(m)
XSV650	338.941	338.8818	-0.0582
XSV652	138.269	137.5813	-0.6877
XSV649	152.770	152.5444	-0.2256
XSV653	236.973	237.1333	0.1603
XSV655	439.886	439.7824	-0.1036
XSV796	145.213	145.2967	0.0837
XSV653AZ	239.495	239.6504	0.1554
XSV795AZ	131.398	131.4955	0.0975
XSV 909	91.672	91.6841	0.0975
XSV999	344.685	344.9231	0.235
	Standard Deviation (SD)		-0.2457
	Root mean square Error (RMSE)		-0.02457

Table 1. Comparison of orthometric heights of the known control points and the values realised from the gravimetric Geoid.

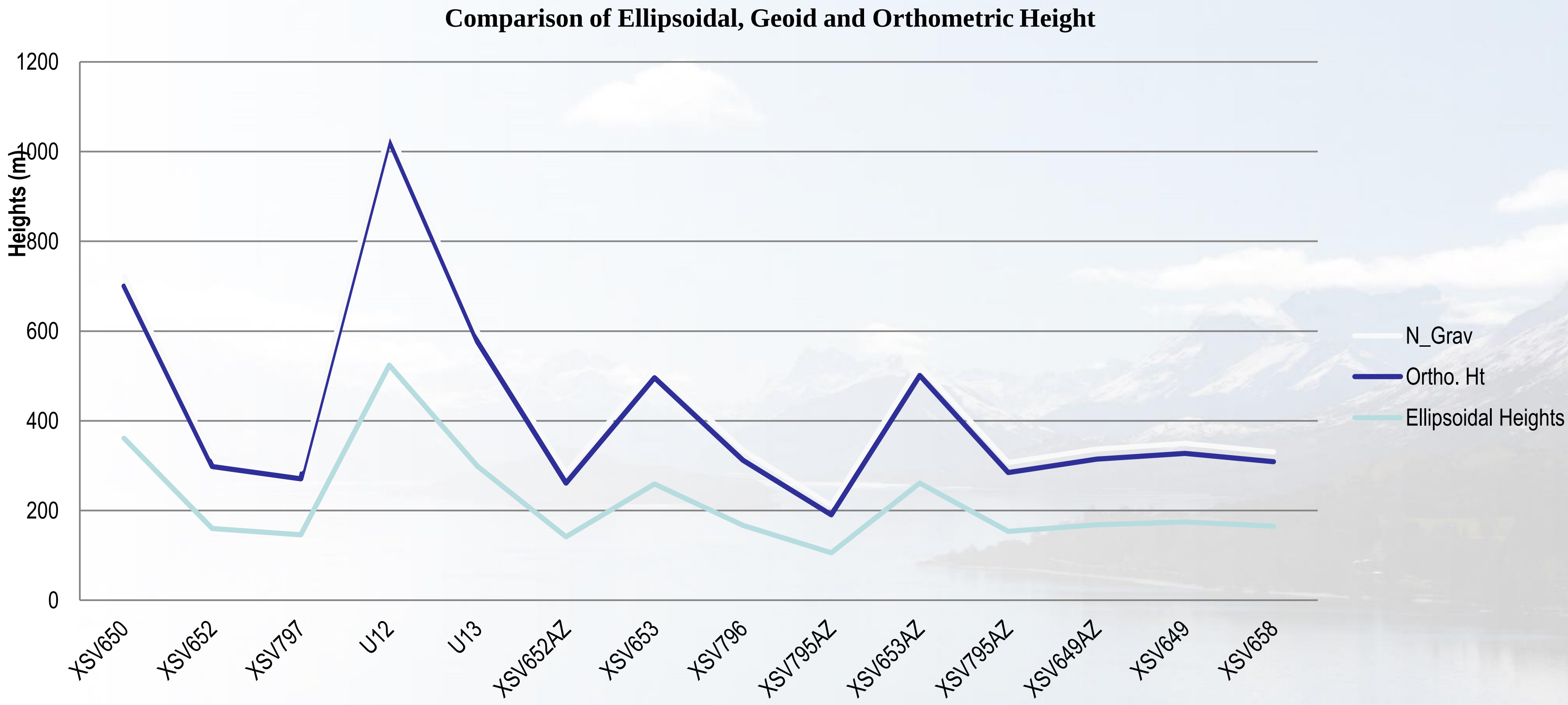


Figure 2: A graphical comparison of the Ellipsoidal, Geoid and Orthometric heights.

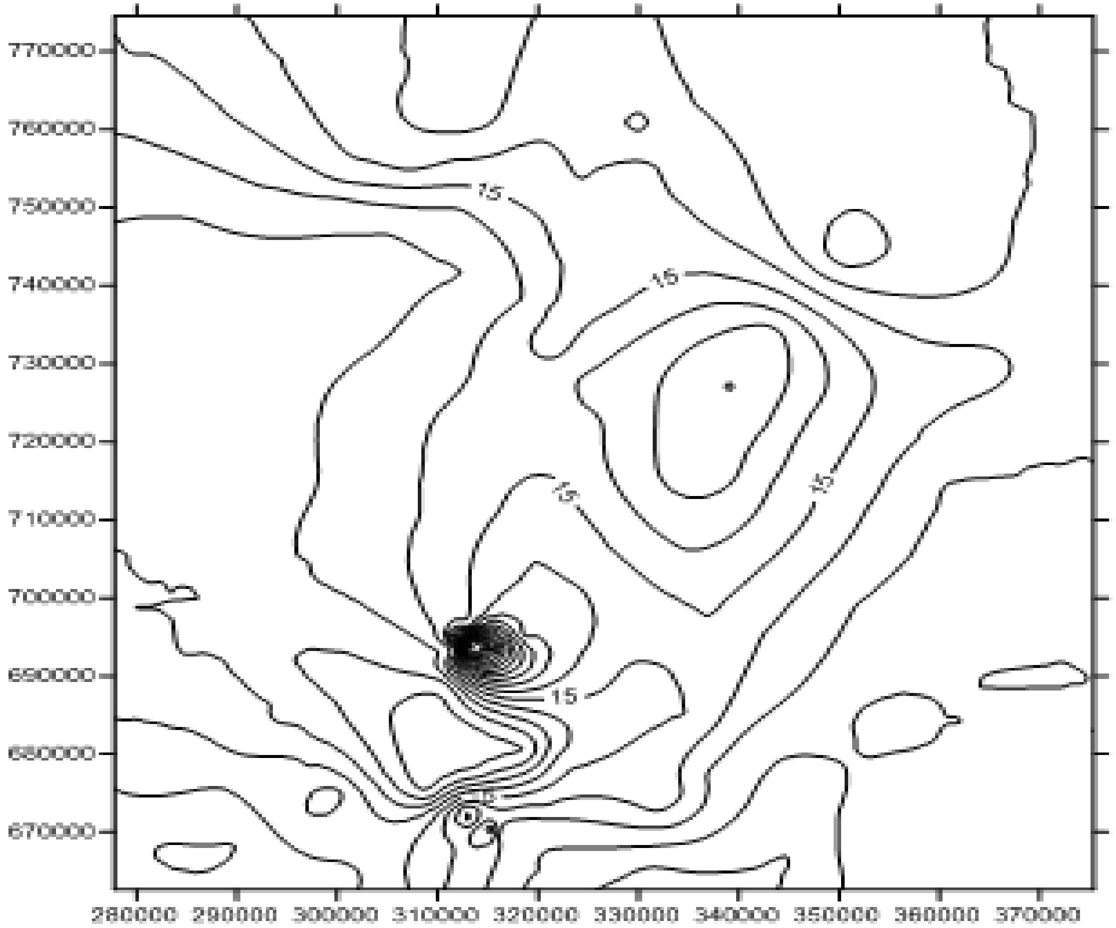


Figure 3: Contour Plot of Gravity Anomaly within the study area.

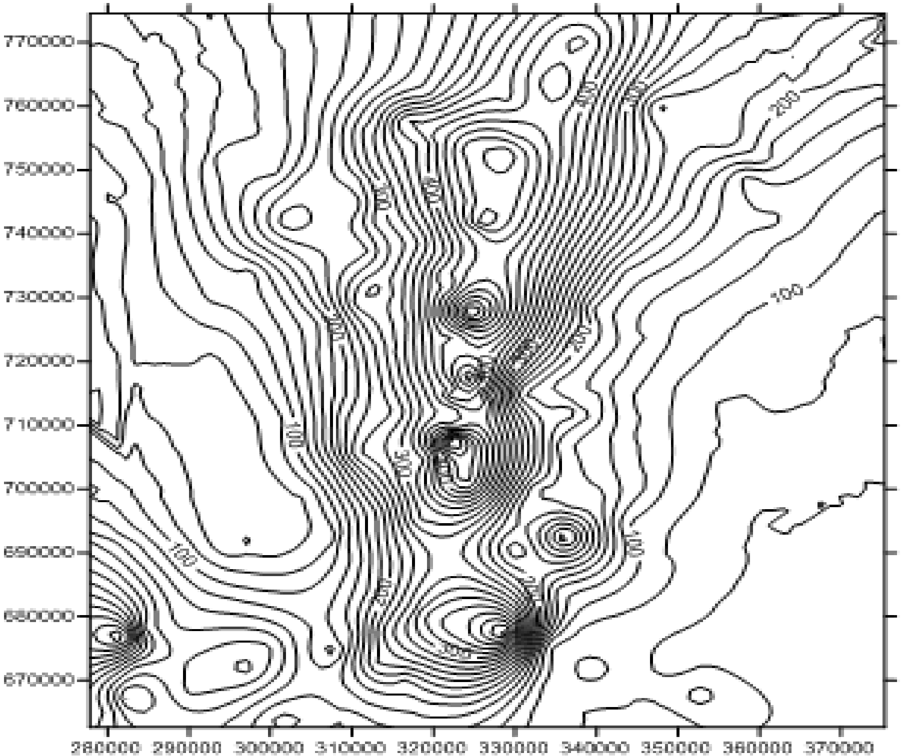


Figure 4: Contour Plot of Ellipsoidal Heights obtained via GNSS post processed static observations within the study area

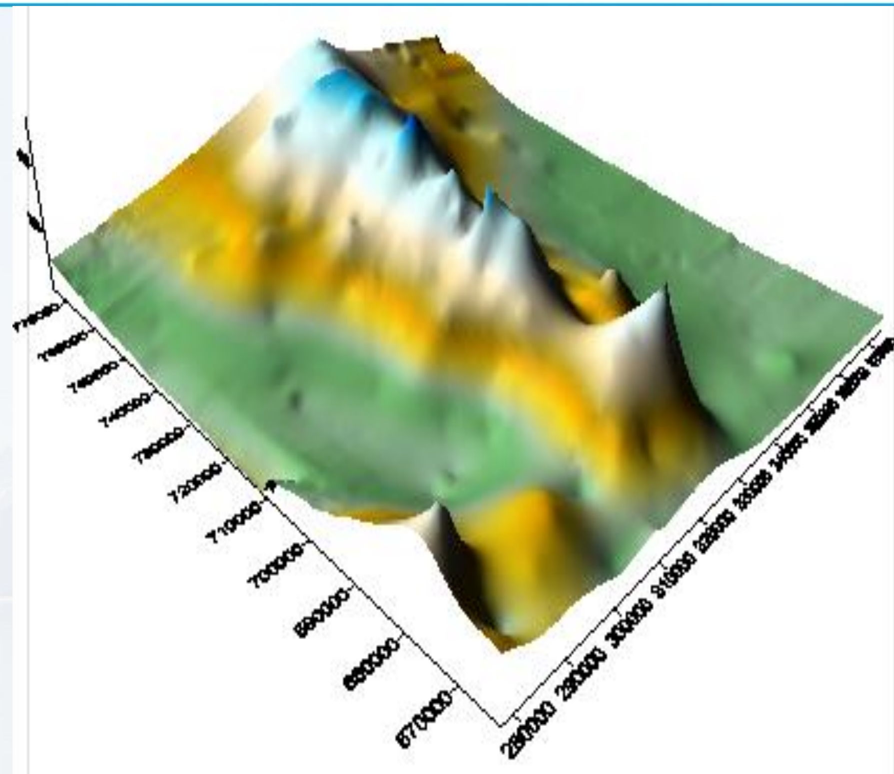
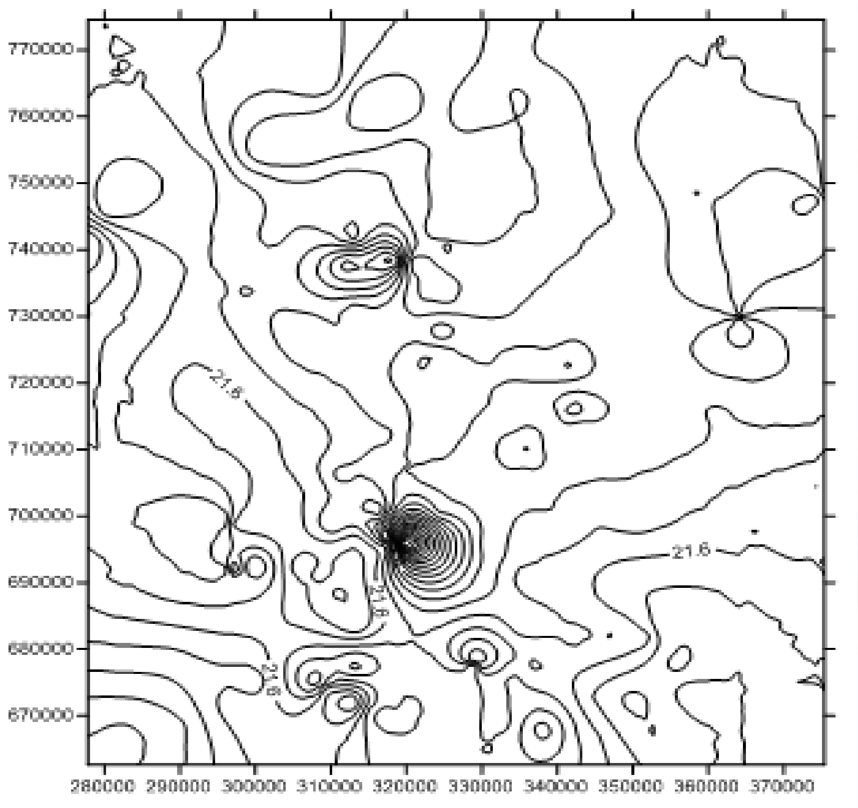


Figure 5: Surface Plot of Ellipsoidal Heights obtained via GNSS.



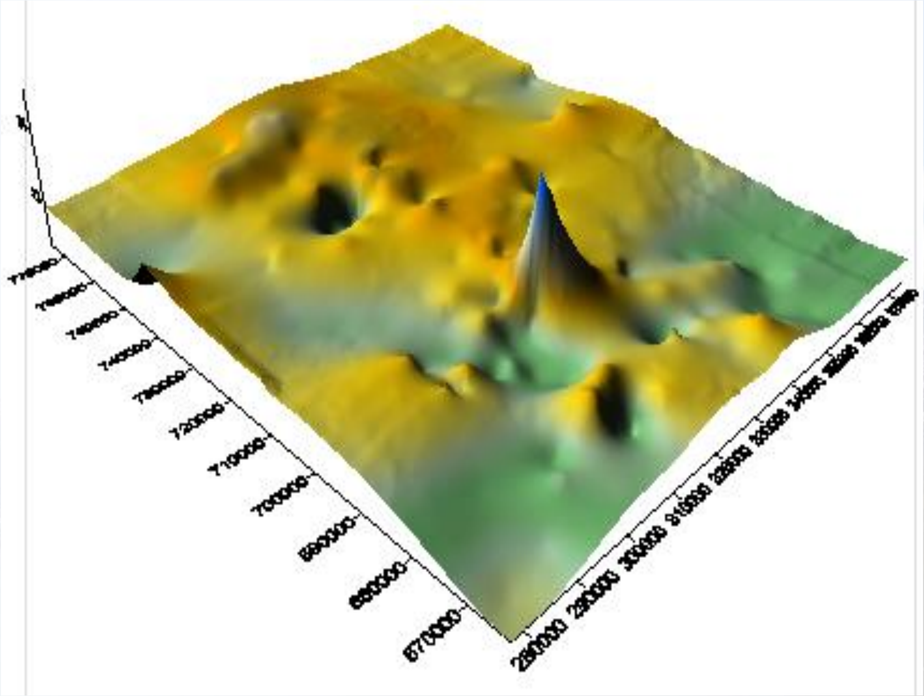


Figure 6: Contour Plot of Gravimetric Geoidal Undulation within the study area

Figure 7: DTM of Gravimetric Geoidal Undulation within the study area

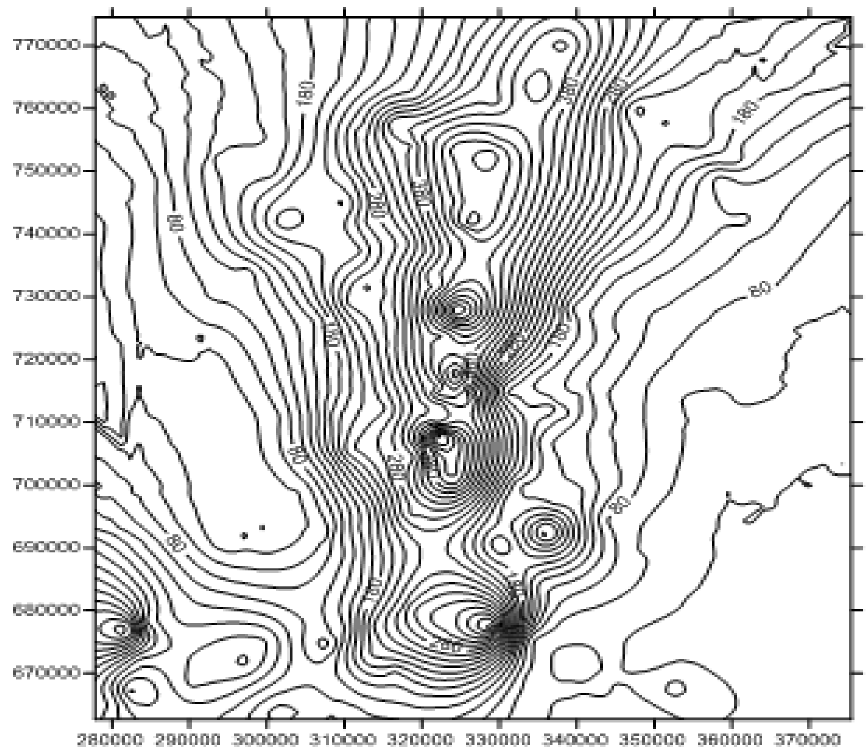


Figure 8: Contour plot of Orthometric heights derived from Gravimetric Geoid model of the study area.

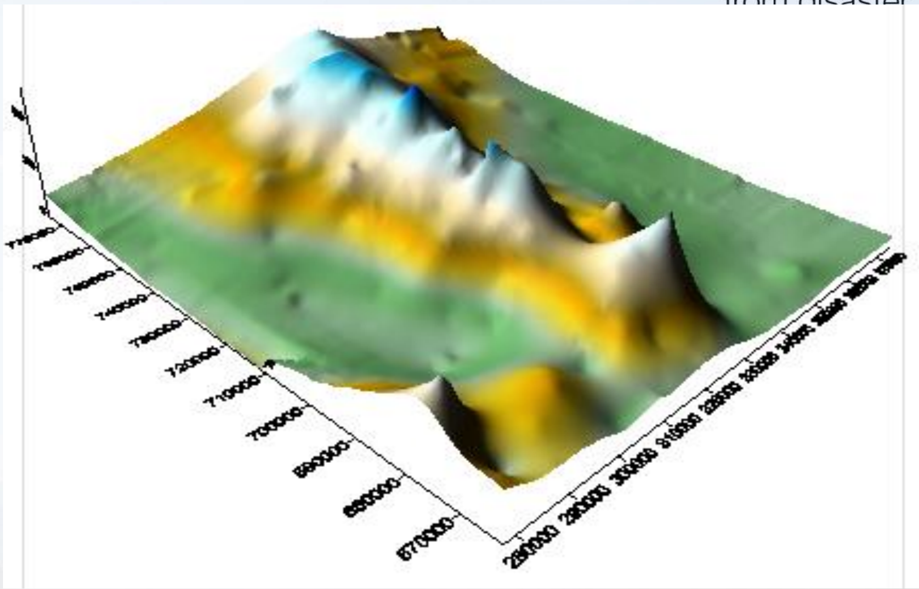


Figure 9: DTM of Orthometric Height of study area.

CONCLUSION

In order to determine the gravimetric Geoid model of the study area, gravimetric observations were made and the classical stokes formula has been applied to obtain the Geoid undulations which were added to the ellipsoidal heights to get orthometric Heights. These terrain models shown above explains to us the reasons why the Geoid has no direct relationship with the land form and therefore does not get affected by changes on the earth surface.

The gravimetric method has proven to be a veritable tool for regional geoid modelling even in highly undulating terrains (as is the case within the study area). Participants are encouraged to read up the full paper for more detail.

THANKS FOR LISTENING