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THE GRAVIMETRIC QUASIGEOID MODEL OVER UGANDA

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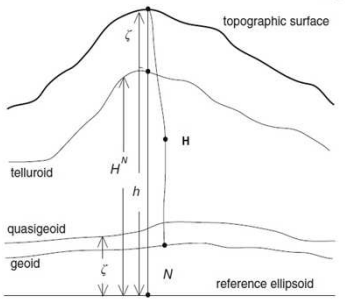
INTRODUCTION

- **Need for geoid/quasigeoid model?---GNSS-HEIGHT DETERMINATION**

$$H = h - N \,/\, H^N = h - \zeta$$

H=orthometric height; h=ellipsoidal height; N=geoid height; H^N =Normal height; ζ =height anomaly/quasigeoid height



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INTRODUCTION

Quasigeoid determination

- **Directly using Stokes formula/modification**

$$\zeta_P = \frac{R}{4\pi\gamma}\iint_{\sigma} S(r_P,\psi)\Delta g^{*} d\sigma$$

- **Indirectly**

$$\zeta_P = N_P + (\zeta - N)$$

$(\zeta - N)$ = quasigeoid-geoid seperation

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INTRODUCTION

Quasigeoid determination

- **Based on the Uganda Gravimetric Geoid Model 2014—KTH method**

$$N^{L,M} = \frac{R}{4\pi\gamma}\iint_{\sigma_0} S^{L}(\psi)\Delta g\, d\sigma + c\sum_{n=0}^{M}\left(Q_n^{L} + s_n\right)\Delta g_n^{GGM} + \delta N_{comb}^{T} + \delta N_{dwc} + \delta N_{tot}^{a} + \delta N_{tot}^{e}$$

σ_0 = spherical cap
R = mean Earth radius
γ = mean normal gravity on reference ellipsoid
$S^{L}(\psi)$ = modified Stokes' function
M = maximum degree of GGM
L = maximum degree of modification
Q_n^{L} = Molodensky truncation coefficients

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Data used for the determination of the geoid model

- 7839 terrestrial gravity data from BGI
- World Gravity Map 2012 surface gravity anomalies –BGI
- SRTM3 DEM—CGIAR-CSI
- GOCE-only GGM—GO_CONS_GCF_2_TIM_R5 (maximum degree=280)
- 10 GNSS/levelling points

Internal & external accuracy assessment of UGG2014

- Internal accuracy= 11.5 cm
- External accuracy before & after 4-parameter fitting = 11.6 cm and 7.4 cm

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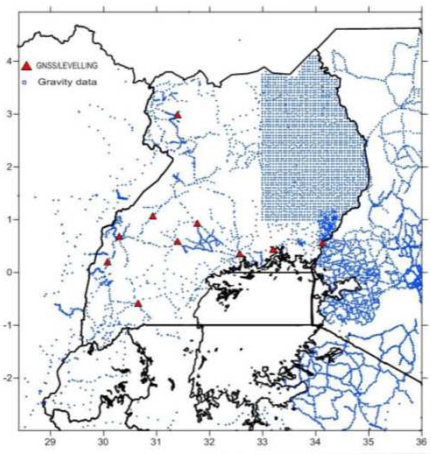
Data used for the determination of the geoid model



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Determination of the quasigeoid-geoid separation

- Approximate formula (Heiskanen & Moritz, 1967)

$$\zeta - N \approx -\frac{\Delta g_B}{\gamma_0} H$$

Δg_B = Bouguer gravity anomaly
H = topograhic height (SRTM3)
γ_0 = normal gravity at latitude 45°

- Strict formula (Sjöberg, 2006;2010)

$$\zeta - \mathrm{N} = \frac{T(r_P,\Omega)}{\gamma_Q(\varphi)} - \frac{T^*(r_g,\Omega)}{\gamma_0(\varphi)} + \frac{V^t_{bias}(r_P,\Omega)}{\bar{\gamma}(\Omega)}$$

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Determination of the quasigeoid-geoid separation

- Comparison of the results of approximate and strict formula for QGGS (Units: m)

Formula	Min.	Max.	Mean	Std.	RMS
Approximate	-0.08	**0.72**	0.16	0.08	0.17
Strict	-0.05	**3.35**	0.17	0.19	0.25

- **Topographic bias in the strict formula ---harmonic series expansion**

$$V^t_{bias}(r_P,\Omega) = 2\pi G\rho_0^t \sum_{n=0}^{n_{max}} \sum_{m=-n}^{n} \left(H^2_{nm} + \frac{2}{3R} H^3_{nm} \right) Y_{nm}(\Omega)$$

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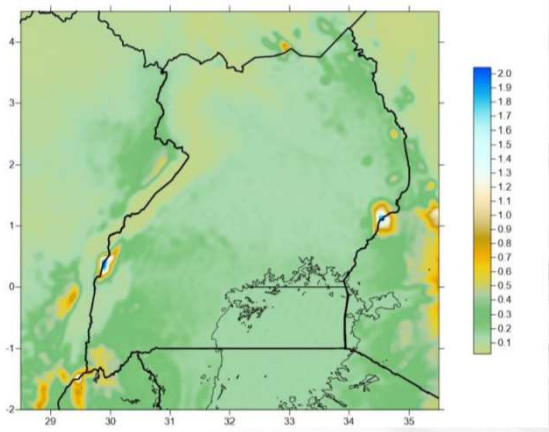
Topographic bias over Uganda



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UGQ2014 & its evaluation

$$\zeta_P = N_P + (\zeta - N)_i$$

GNSS/levelling residuals over 10 points before and after the 4-parameter fit (units: cm)

Formula		Min	Max	Mean	Std.	RMS
Approximate	Before	2.56	51.41	24.10	12.74	**29.96**
	After	-20.46	13.80	0.0	10.90	**10.34**
Strict	Before	-30.54	14.56	-9.29	13.18	**15.57**
	After	-9.96	12.91	0.0	6.65	**6.31**

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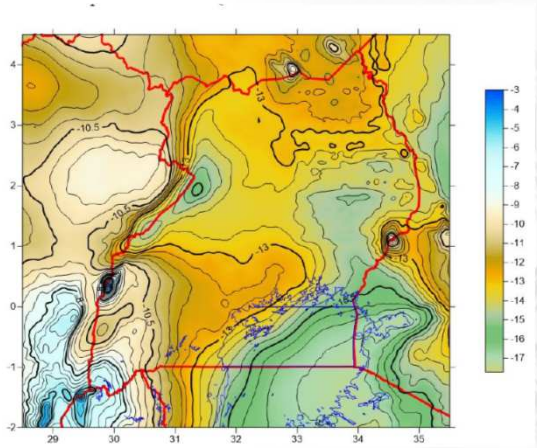
UGQ2014



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Conclusion

- Standard errors of ellipsoidal heights = 2.2 cm
- Standard errors of normal-orthometric heights = 1.0 cm
- **Standard error of UGQ2014 before & after fitting are 15.4 cm and 5.8 cm**
- **Satisfactory given the poor quality & quantity of terrestrial gravity data**
- **Comparison of approximate & strict formulas shows that --- introduce errors of 2.6 m in the QGGS --- 35 cm in the final quasigeoid heights**
- **Future work ---**
  - GNSS/levelling observations to create a more homogeneous dataset
  - Government– airborne gravimetry for better quality gravity data

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