FIG 2018 ISTANBUL

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ISTANBUL

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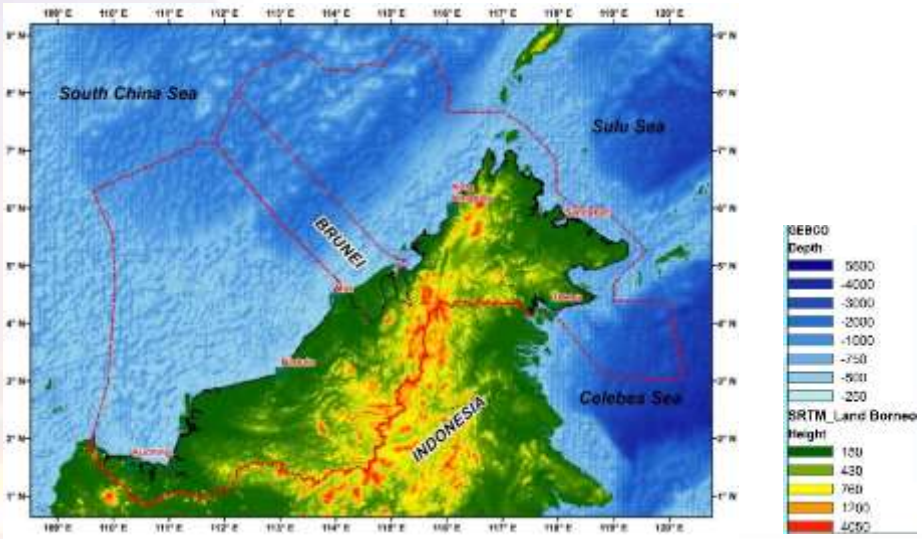
GEOID BASED HEIGHT SYSTEM FOR EAST MALAYSIA (9529)

By

Mohd Nor Isa, Azhari Mohamed, Sohaimi Rasidi, Zulkifly Chihat and Abd Majid A Kadir

FIG 2018 ISTANBUL
9th May, 11:00 – 12:30 HALL 1



This presentation will discuss on:
the adoption of a new seamless land-to-sea gravimetric geoid determined from airborne gravity data covering an area of about 610,000 square kilometre as height datum for East Malaysia–

This geoid-based height datum will enable cost-saving implementation GPS-levelling, easily accessible at any point in East Malaysia, and is less sensitive to local ground instability and the deterioration of benchmarks.

LOCAL MEAN SEA LEVEL VERSUS GEOID AS THE GEODETIC VERTICAL DATUM

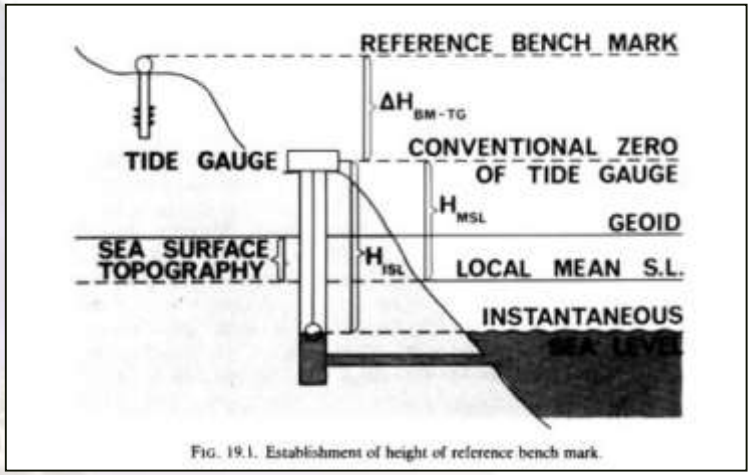


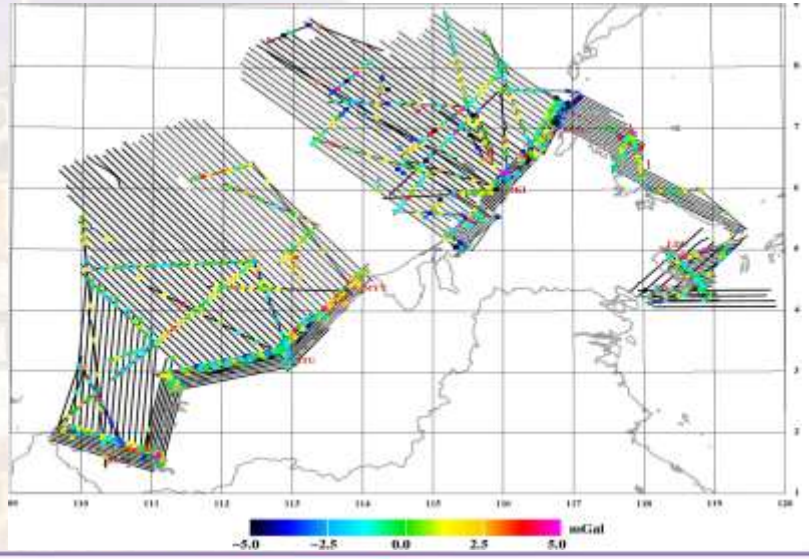
FIG. 19.1. Establishment of height of reference bench mark.

The Peninsular Malaysia Geodetic Vertical Datum (PMGVD) and East Malaysia Geodetic Vertical Datum (EMGVD) was constructed using classical levelling techniques by the Department of Surveying and Mapping Malaysia (DSMM).

GPS users require 3D positions referenced to the Geocentric Datum of Malaysia (GDM2000). Therefore, the modernization of the vertical component of the GDM2000 is critical in providing Malaysians with a truly three- dimensional integrated datum.

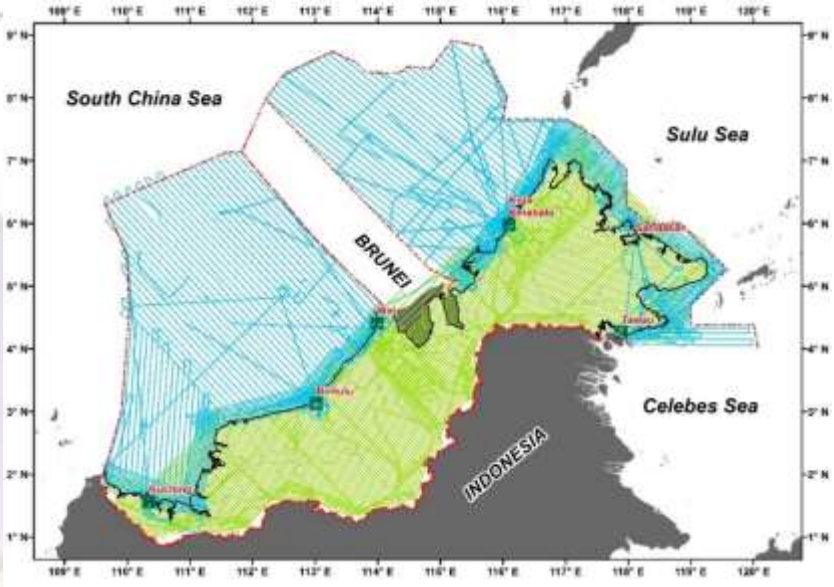
AIRBORNE GRAVITY SURVEY AND GRAVIMETRIC GEOID DETERMINATION

In collaboration with Prof. Rene Forsberg, DTU-Space, Denmark.

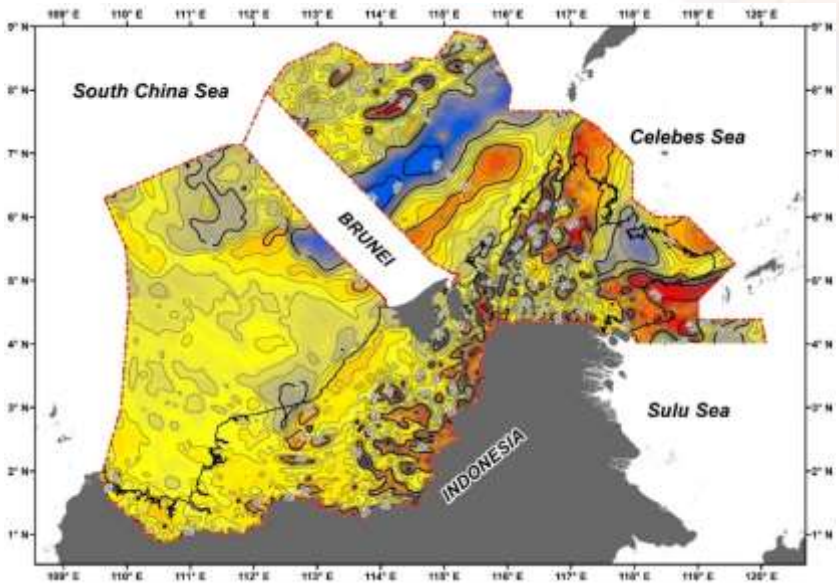


Year	RMS Crossing	Max	Line Error Estimate	Cross-Over Points
2002-2003	3.2	9.9	2.2	1311
2014	3.0	9.0	2.1	72
2015	2.3	7.1	1.7	389
2016	1.9	5.4	1.5	336

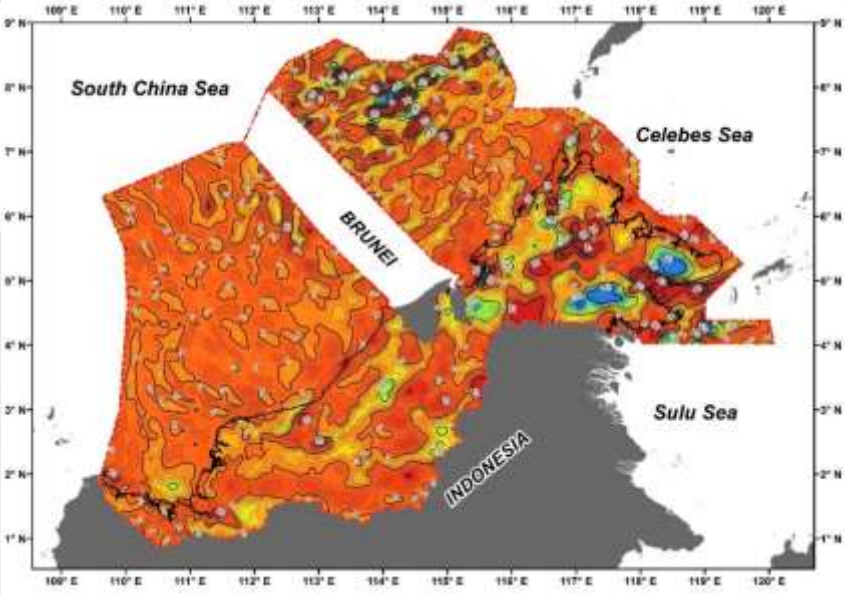
Jamil, H. et al., Airborne Geoid Mapping of Land and Sea Areas of East Malaysia, Journal of Geodetic Science, DE GGRUYTER OPEN, 2017



Airborne gravity survey of East Malaysia (green and blue lines indicate airborne survey over land and marine areas, respectively).

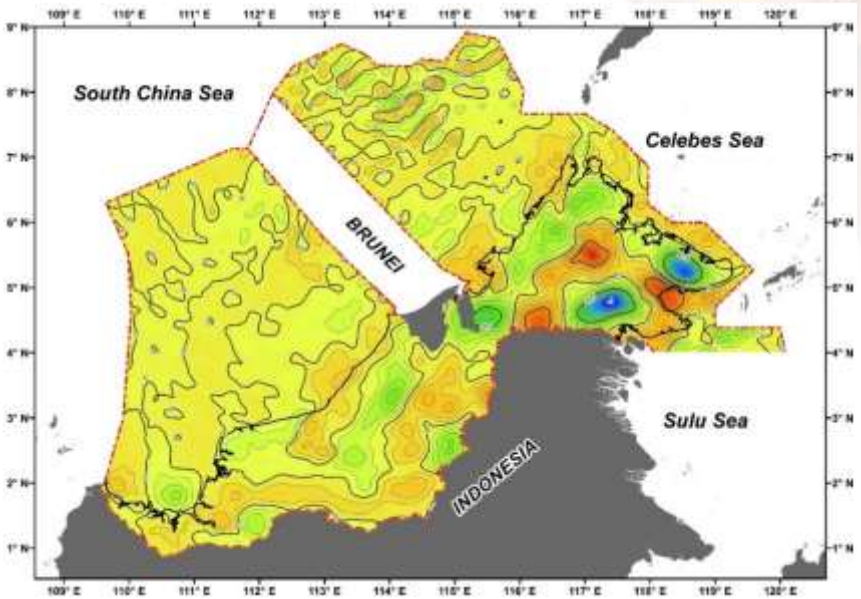


Downward continued Free-air gravity anomaly map in 10 mGal contours, gridded at 1.5 arc minute.

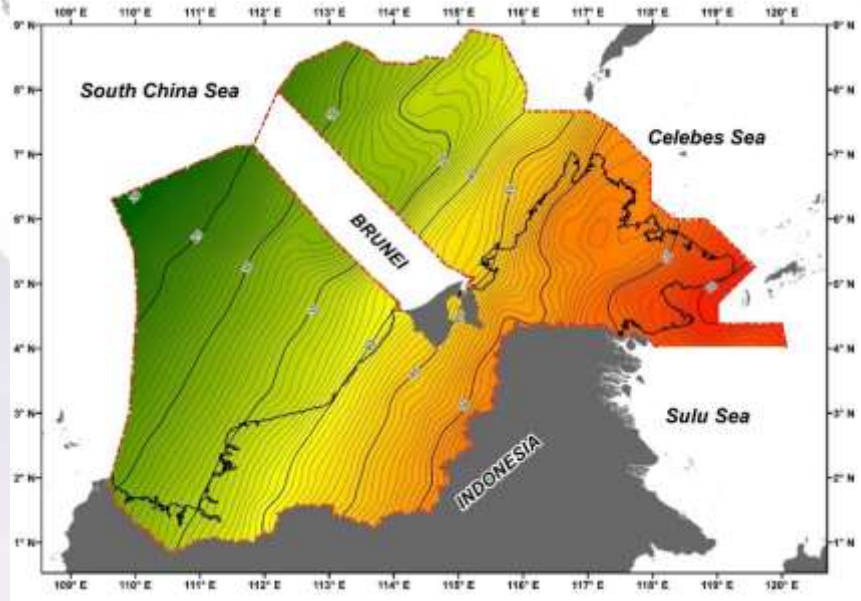


REMOVE-COMPUTE-RESTORE TECHNIQUE

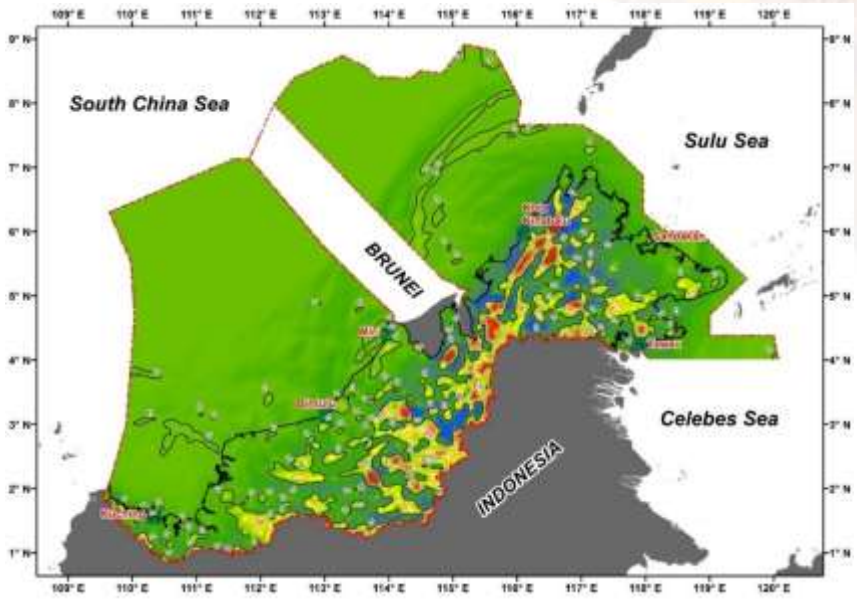
Remove: Remove reference field and RTM effects to get residual Free-air gravity anomaly (Δg_{res})



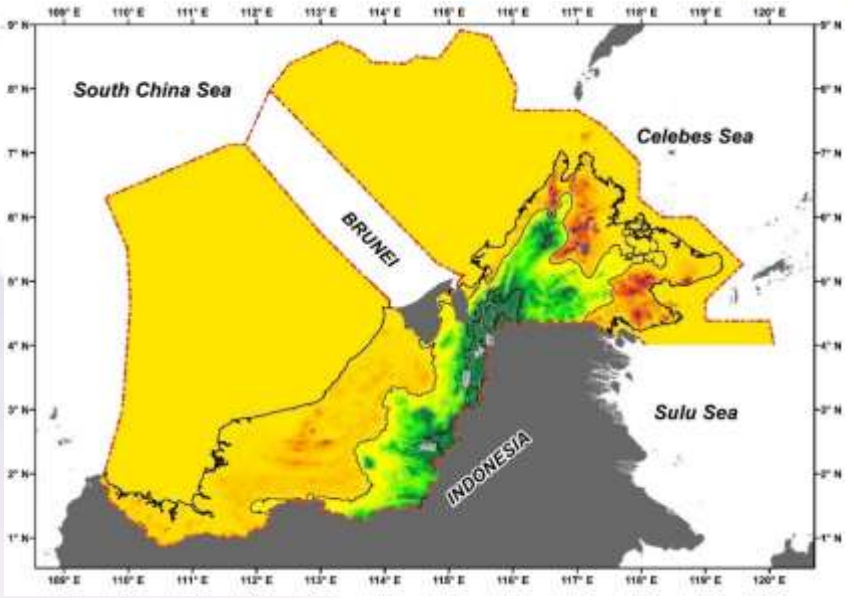
Compute residual height anomaly (ζ_{res}), using Fast Fourier Transform (FFT) technique/ GRAVSOFT software



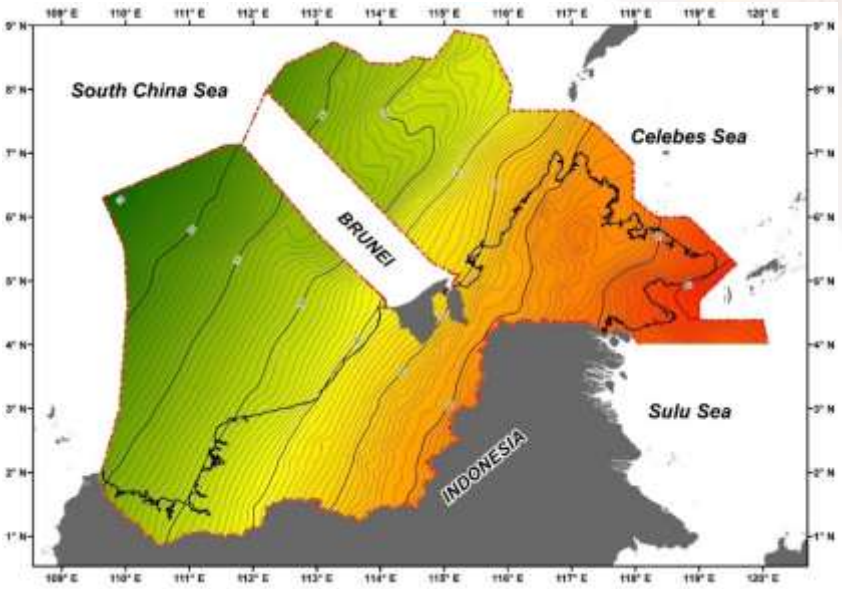
Add EGM08/GOCE reference geoid (ζ_{EGM})



Add RTM geoid (ζ_{RTM})

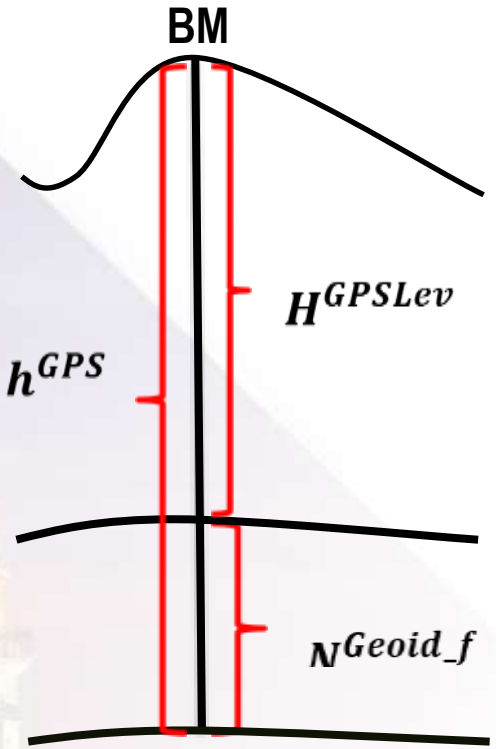


Add quasi-geoid to geoid correction ($N - \zeta$).



Final gravimetric geoid of East Malaysia in 0.5 m contours

GEOID BASED VERTICAL DATUM



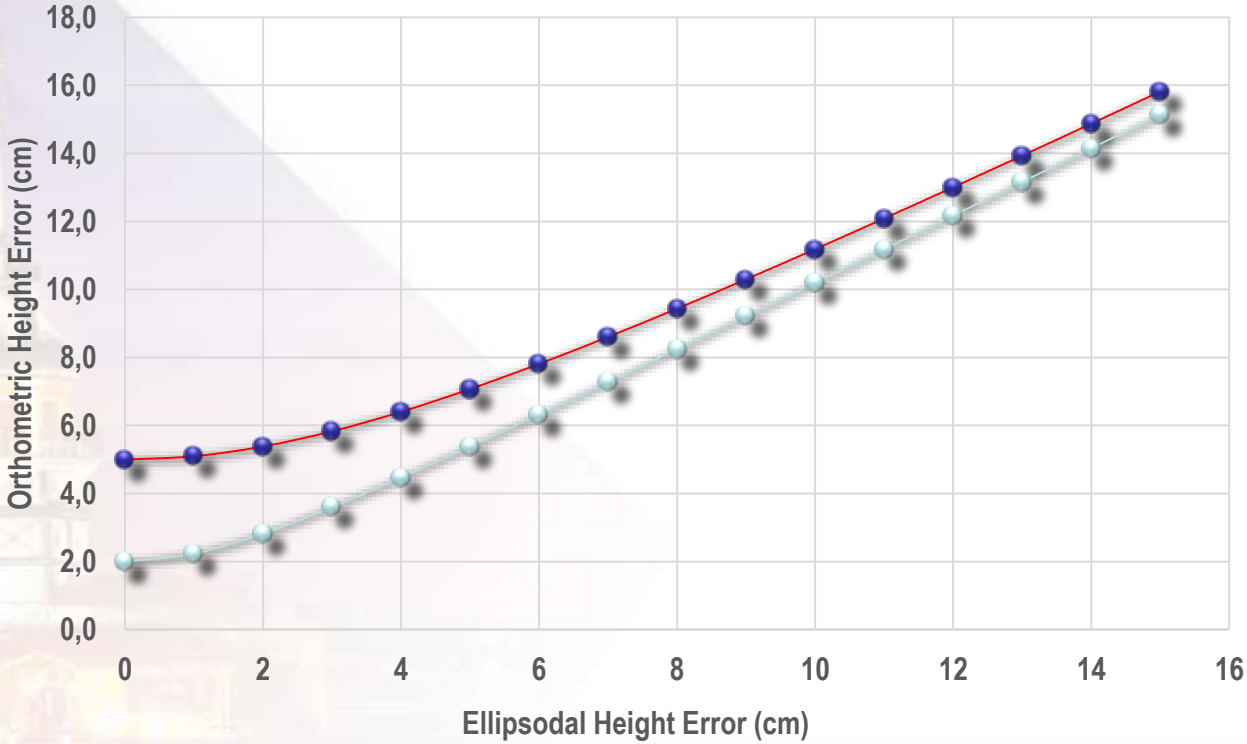
$$H^{GPSLev} = h^{GPS} - N^{Geoid}$$

Geoid Based Vertical Datum: ***Gravimetric Geoid Fiited to Local MSL***

GDM2000/GRS80 Elliposoid

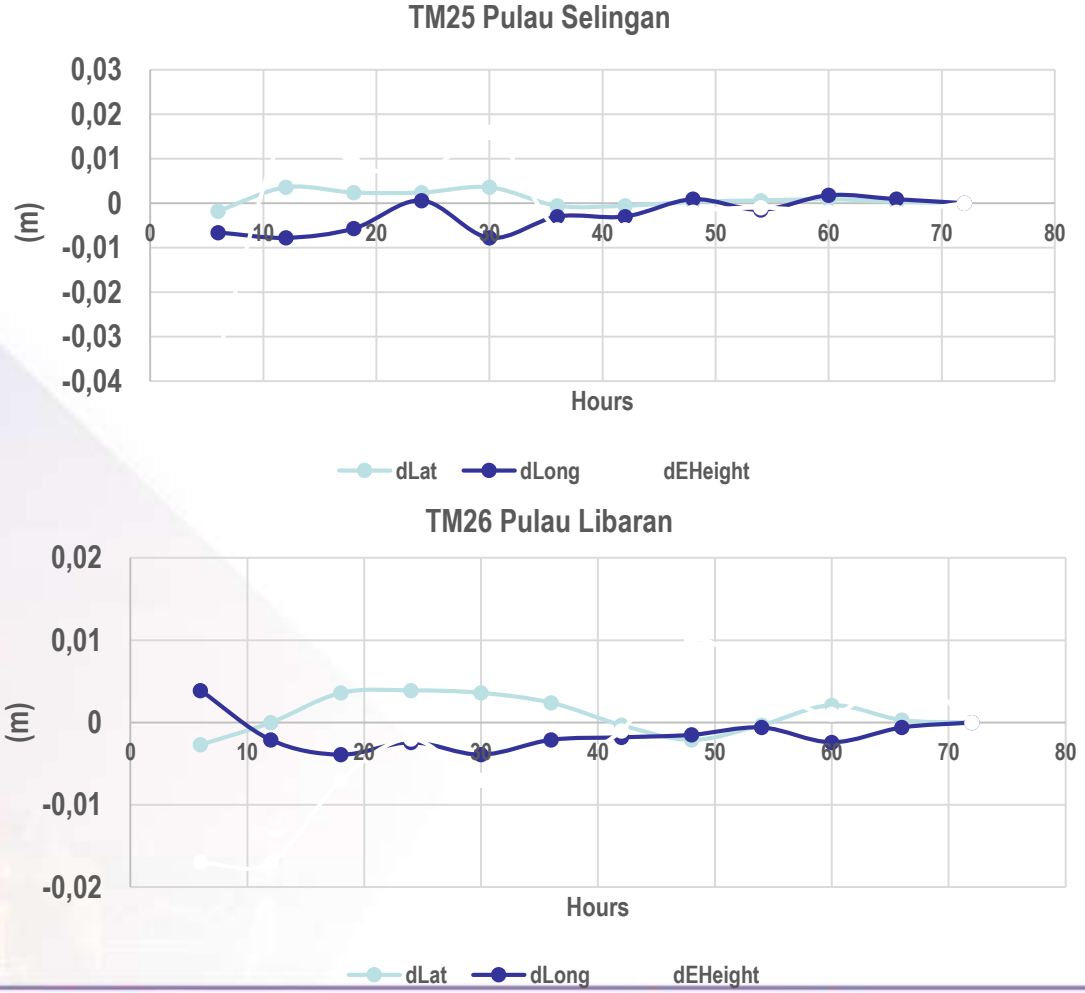
The outcome of the remove-restore technique is a gravimetric geoid, referring to an implicit global height datum; to adapt the geoid to fit the local vertical datum, a *fitting* of the geoid to GPS/tide gauge control is needed as the final geoid determination step.

Achievable absolute accuracy for geoid-based height system, with estimated gravimetric geoid accuracies of 2cm to 5cm. In order to minimise the error propagation $\sigma_H = \pm(\sigma_h^2 + \sigma_N^2)^{½}$, the ellipsoidal height accuracy has to be less than ±1 cm.



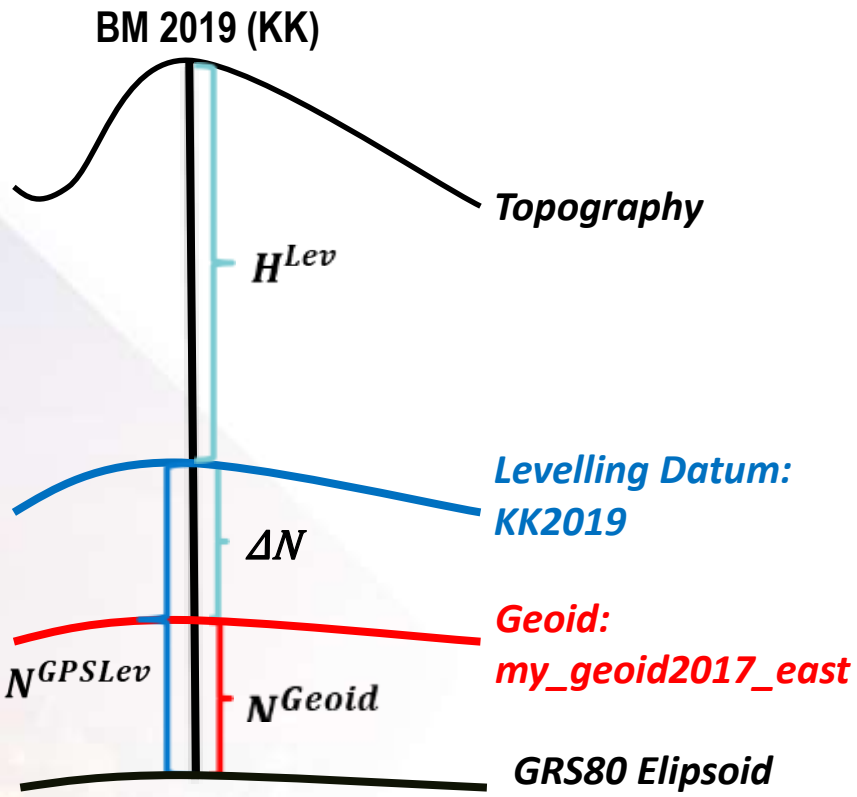
GPS ELLIPSOIDAL HEIGHT DETERMINATION

AUSPOS POSITIONING ACCURACY VERSUS OBSERVATION SESSION LENGTH



It is clear from these figures that the 3D coordinate solution converged to less than **1 cm** at about **48 hours** of observation length. For a **12 hours** of GPS observation session, the ellipsoidal height is expected to be accurate to **2 cm.**

GRAVIMETRIC GEOID FITTING TO LEVELLING DATUM



Fitted geoid with respect to levelling datum at BM2019 in Kota Kinabalu

$$\Delta N = N^{GPSLev} - N^{Geoid}$$
$$= 48.314 - 47.422$$
$$= +0.892 \text{ m}$$

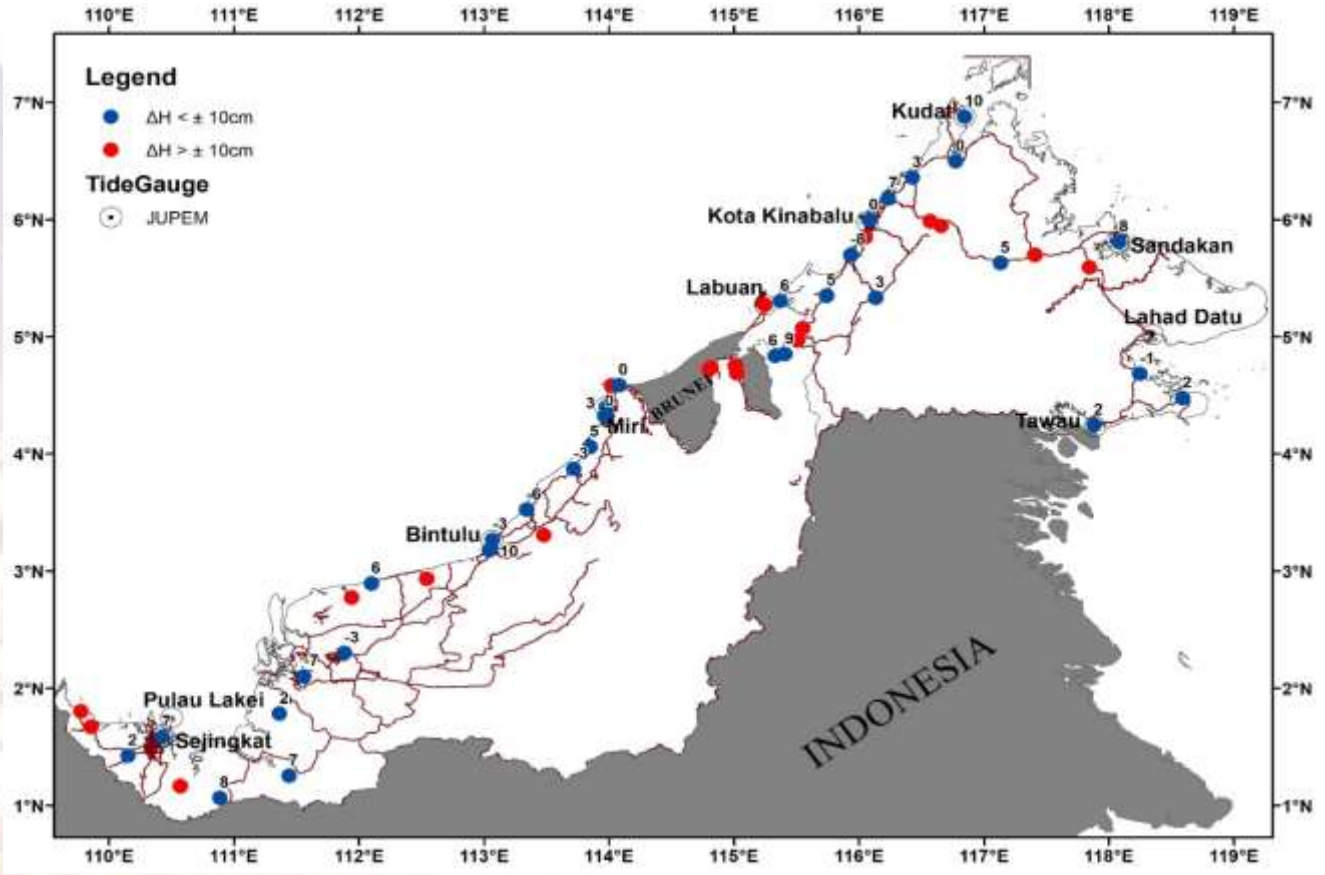
$$N_{GPSLev} = N_{Geoid} + \Delta N$$
$$= my\_geoid2017\_kk\_fit$$
$$my\_geoid2017 + 0.892 \text{ m}$$

The final geoid was then fitted to all the six tide gauge stations and is known as *my_geoid2017_fit_east*.

GPS/levelling analysis at five tide gauge locations in East Malaysia relative to Kota Kinabalu levelling height datum

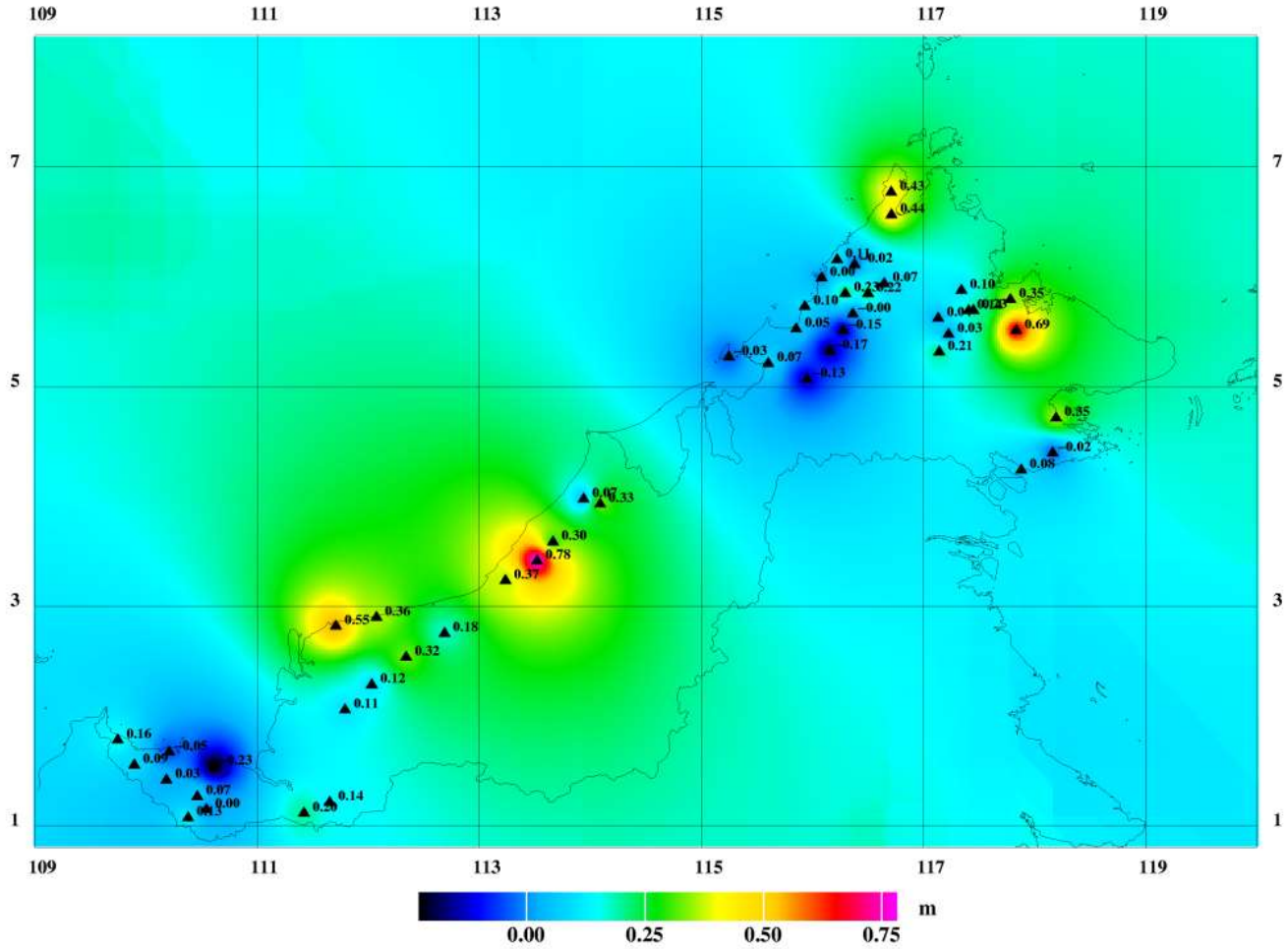
Station ID	Nearest Tide Gauge Station	GPS Ellipsoidal Height h^{GPS} (m)	Geoid Height $N^{2017\_fit\_kk}$ (m)	Geoid Based Height $H^{GPS\ Lev}$ (m)	Leveling Based Height H^{Lev} (m)	$\Delta H = H^{Lev} - H^{GP\ Lev}$ (cm)
BM2019	**Kota Kinabalu (fitted station)**	51.947	48.314	3.633	3.633	**0.0**
STDM	**Tawau**	61.011	57.612	3.399	3.381	**1.8**
K013	**Kuching**	37.477	34.028	3.449	3.380	**6.9**
T002	**Bintulu**	46.194	40.794	5.400	5.428	**-2.8**
0133	**Miri**	44.402	41.736	2.666	2.663	**0.3**
G118	**Lahad Datu**	71.911	59.475	12.436	12.441	**-0.5**
					RMS	**3.1**

EAST MALAYSIA LEVELLING NETWORK VALIDATION



Due to difficult terrain and poor accessibility in East Malaysia, the levelling network is available only in the coastal areas.

GPS levelling residuals $\Delta H = H^{Lev} - H^{GPSLev}$ in cm at 50 GPS-levelling benchmarks. RMS of blue circles = 4.9 cm



Differences between *MyGeoid_2003* and *my_geoid2017_fit_east*, *Large differences mainly due to GPS levelling errors in 2003 solution.*

CONCLUSIONS

- The accuracy of the new gravimetric geoid based height system (*my_geoid2017_fit_east)* is estimated to be 2 to 5 cm across most of East Malaysia.
- The new height datum will not change the heights assigned to benchmarks across East Malaysia as the geoid datum has been fitted to levelling datum at selected tide gauge stations.
- We have found no noticeable sea-surface-topography slope (gravimetric geoid minus DTU15 mean sea surface height) along East Malaysia coast and therefore no significant differences in levelling height datums across East Malaysia.
- For geoid fitting to local MSL, GPS ellipsoidal height has to be determined with accuracy of less than 1 cm (AUSPOS processing with a minimum of 48 hours of GPS observation at tide gauge benchmark -TGBM).
- The official *MyGeoid_2003* for East Malaysia has to be replaced with *my_geoid2017_fit_east.*
- A seamless land/sea geoid-based-height system also will further enhance the development and management of the marine environment.