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“From the Wisdom of the Ages to the Challenges of the Modern World”

Determination of Gravimetric Geoid Model in Sulawesi – Indonesia

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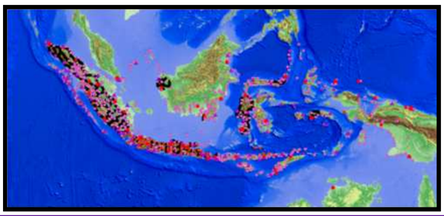
Outline

- Introduction
- Height System in Indonesia
- Gravimetric Geoid Model Computation Method
- Result And Analysis
- Conclusion



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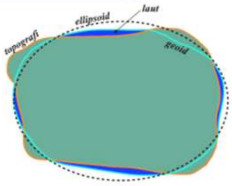
Introduction



- In 2013, Indonesia has a new reference system ➔ SRGI2013
- SRGI2013 ➔ geoid as the national vertical reference (Perka BIG 15/2013, article 10(1))
- The efforts to determine the Indonesian local geoid model has been done since the 1980s until 2000s ➔ Terrestrial gravity measurement ➔ 5871 gravity measurement points ➔ ineffective and inefficient

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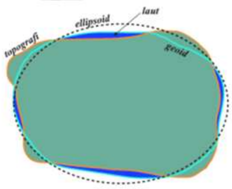
Introduction



- In 2008 the gravity measurement started to be carried out using Airborne Gravity technology ➔ DTU Denmark and BIG Indonesia
- Airborne method ➔ faster completion of the necessary gravity data for the National Geoid model
- This research aims ➔ determining the gravimetric geoid model in Sulawesi using data from airborne gravity survey and other supporting data.

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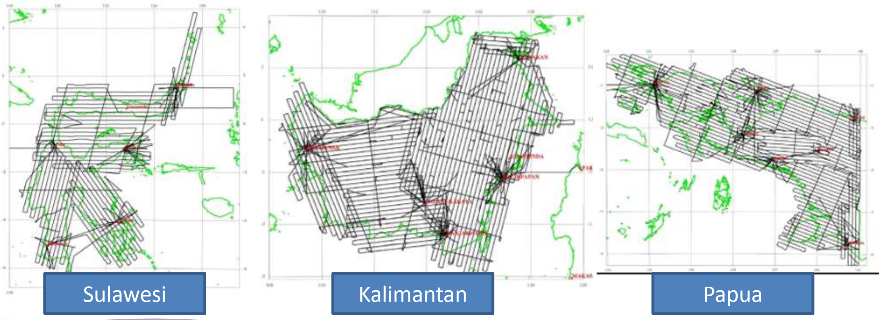
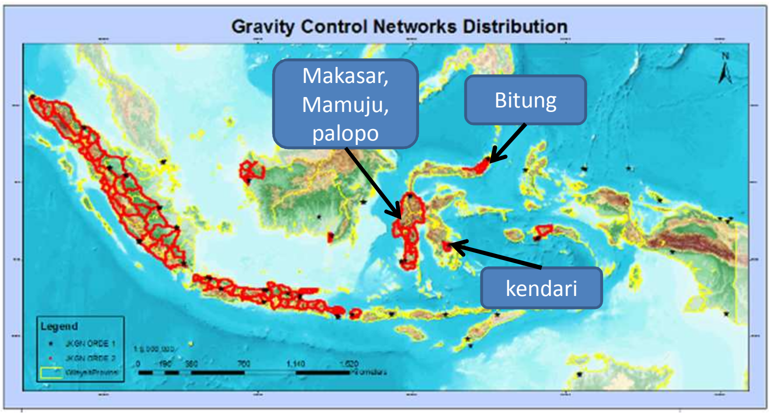
Airborne Gravity Survey

- To model the geoid in Indonesia, a dense gravity data in the area are required ➔ short time ➔ airborne gravity technology ➔ 2008-2011



Height System In Indonesia

- **Spirit Leveling ➔ Vertical Control Network ➔ Orthometric Height**



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Height System In Indonesia

- **Spirit Leveling**
  - The spirit leveling measurement is tied to the Mean Sea Level (MSL) of each island
  - The orthometric heights at Vertical Benchmark are not continuous ➔ MSL has local characteristics
  - MSL can be used as a height reference if there is no disturbance ➔ Never met
  - MSL is always dynamic and affected by meteorology and oceanography condition
  - MSL ➔ Geoid

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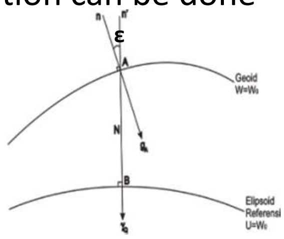
GRAVIMETRIC GEOID MODEL COMPUTATION METHOD

- **Gravimetric Geoid**
  - Gravimetric geoid determination can be done using gravity data
  - Stokes formula :

$$N = \frac{R}{4\pi G} \iint_{\sigma} \Delta g . S(\Psi) d\sigma$$



  - The Stokes formula requires a well distributed gravity data and cover the whole earth to model an accurate geoid model ➔ difficult to provide such data

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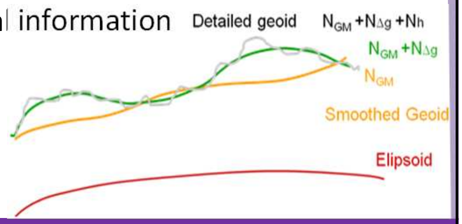
GRAVIMETRIC GEOID MODEL COMPUTATION METHOD

- **Gravimetric Geoid**
  - Dividing the geoid signals into three components :
    - Longwave component ➔ global information ➔ Satellite gravimetry
    - medium wavelength ➔ regional information ➔ terestrial gravity data
    - Short wavelength ➔ local information ➔ topography model



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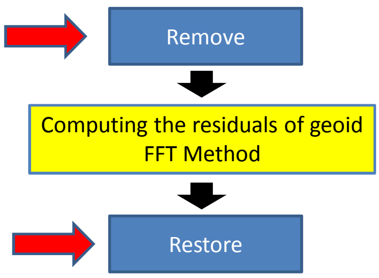
GRAVIMETRIC GEOID MODEL COMPUTATION METHOD

- **Gravimetric Geoid**
- The computation steps of the geoid model using remove-restore

Δgres = ΔgFA - ΔgGM - Δgh



Ngeoid = ΔNres + ΔNGM + ΔNh

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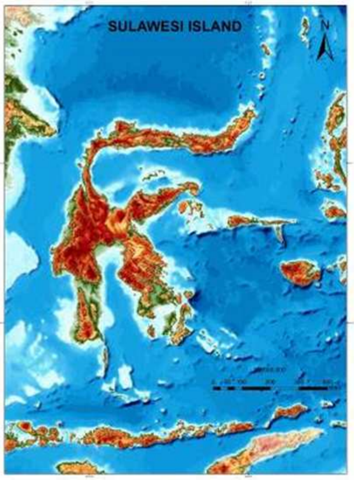
Case Study



- -6.5° S until 4.5°N and 118° until 126° E
- The medium wavelength data as obtained from airborne gravity survey and the Vertical Control Network are more evenly distributed that the other two islands

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Data and Tools

- Long wave ➔ Global Geopotential Model (GGM) ➔ EGM08+GOCE ➔ modified by DTU
- Medium wave ➔ The free air anomaly from the airborne gravimetric in Sulawesi Island
- Short wave ➔ terrain data are corrected using SRTM30
- data are then processed in Gravsoft Package Software

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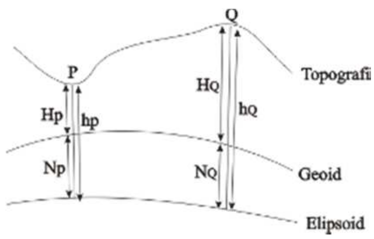
GRAVIMETRIC GEOID MODEL COMPUTATION METHOD

- **Geometric Geoid**
- The geoid undulation (N) is obtained from the height difference between ellipsoid or geometric height (h) and orthometric height (H)

N = h –H



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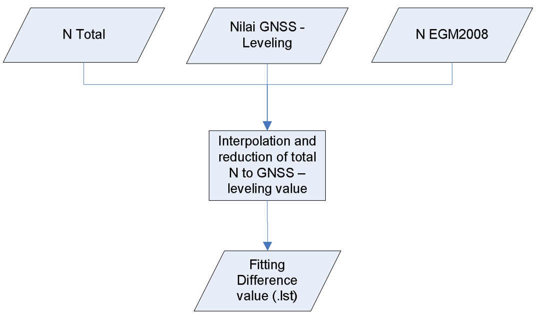
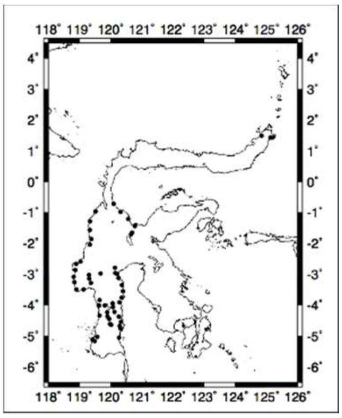
Geoid Validation





The vertical benchmarks used in the validation were measured **in 2010 and 2013**. As many as 54 points were used to validate the geoid.

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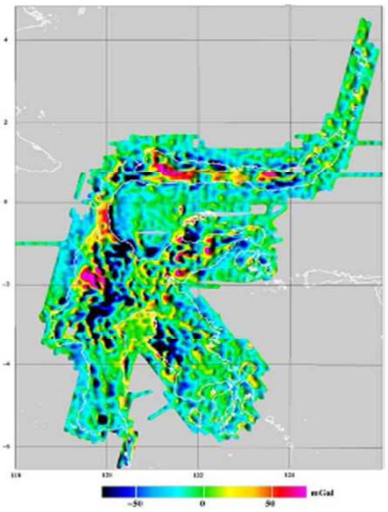
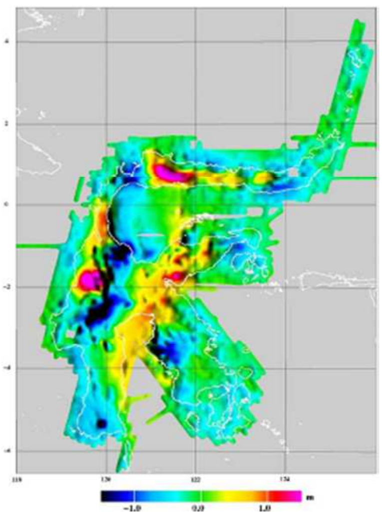
RESULT AND ANALYSIS



- FAA residual (Anomaly gravity residual)
- FAA deficiency against the global model EGM08 by -60 mgal to 60 mgal
- FAA signals in that range cannot be detected if using only the global model

RESULT AND ANALYSIS



- Geoid residuals in Sulawesi
- The global model is not capable to detect the small variations in the geoid
- The geoid deficiency against the global model EGM08 by -1 meter to 1 meter

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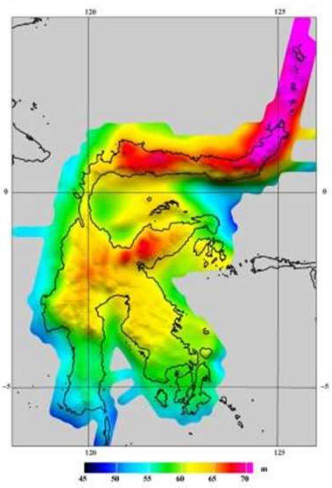
RESULT AND ANALYSIS



- The gravimetric geoid model of Sulawesi
- The pattern of geoid in Sulawesi is that the value of the geoid increases from sothwest to northeast, with the geoid height range between 45-80 meter.

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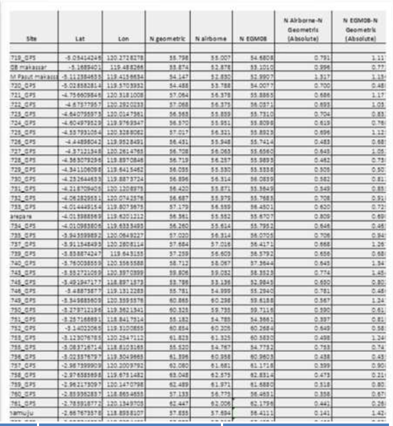
Validation



	N Airborne – N Geometris (M)	N EGM08 – N Geometris (M)
mean	0.657	0.870
STDev	0.2403	0.3589
RMS	0.6987	0.9437

- The value of geoid standard deviation from airborne gravity result is smaller than that from EGM08
- The accuracy of the geoid model from airborne gravity measurement is 69 cm, while the EGM08 geoid model has the accuracy of 94 cm

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Comparison of airborne gravity N and EGM08 N partially

Statistic	N Airborne-N Geometric	N EGM08-N Geometric
	South Sulawesi	South Sulawesi
Average	0.66606367	0.865454579
Stdev	0.16821467	0.279395187
RMS	0.686352336	0.908134238
	Central Sulawesi	Central Sulawesi
Average	0.49514	0.764666667
Stdev	0.166689312	0.524247735
RMS	0.520669369	0.917185052
	North Sulawesi	North Sulawesi
Average	1.011360835	1.020377502
Stdev	0.351501671	0.634774851
RMS	1.061042849	1.173436338

Validation

- The gravimetric geoid from airborne gravity measurement can improve the accuracy of global geoid model EGM 2008 by 22 cm in South Sulawesi, 39 cm in Central Sulawesi, and 11 cm in North Sulawesi. While for the island as a whole, the gravimetric geoid from airborne gravity measurement can improve the accuracy of EGM 2008 by 25 cm.

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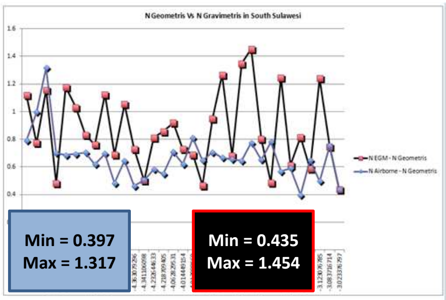
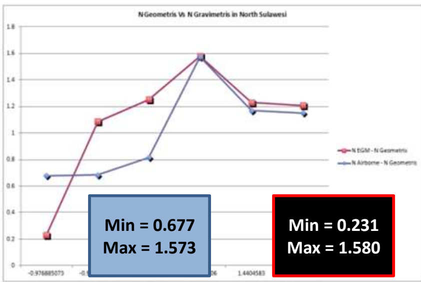
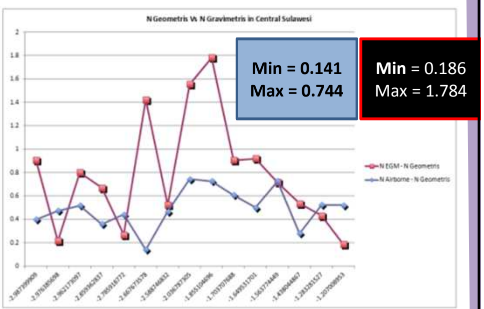
Validation







- The geoid model from airborne gravity measurement has better consistency, as can be seen from the undulation difference

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CONCLUSION

- The utilization of airborne gravity for the determination of gravimetric geoid model in Indonesia is very beneficial, because this survey allows a faster determination of Indonesian geoid model with a high accuracy, improving the precision of global geoid model, by 25 cm in Sulawesi Island.

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