



FIG WORKING WEEK 2015
SOFIA – BULGARIA 17-21 MAY 2015
“From the Wisdom of the Ages to the Challenges
of the Modern World”



Determination of Gravimetric Geoid Model in Sulawesi – Indonesia



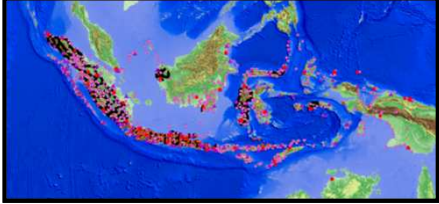
Arisauna PAHLEVI, Dyah PANGASTUTI, Nabila
SOFIA, Adolfientje KASENDA, Kosasih PRIJATNA





Outline

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



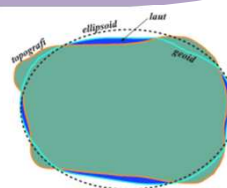



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Introduction

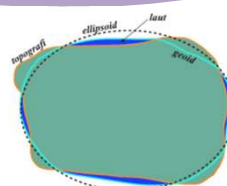


- In 2013, Indonesia has a new reference system → SRGI2013
- SRGI2013 → geoid as the national vertical reference (Perka BIG 15/2013, article 10(1))
- The efforts to determine the Indonesian local geoid model has been done since the 1980s until 2000s → Terrestrial gravity measurement → 5871 gravity measurement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

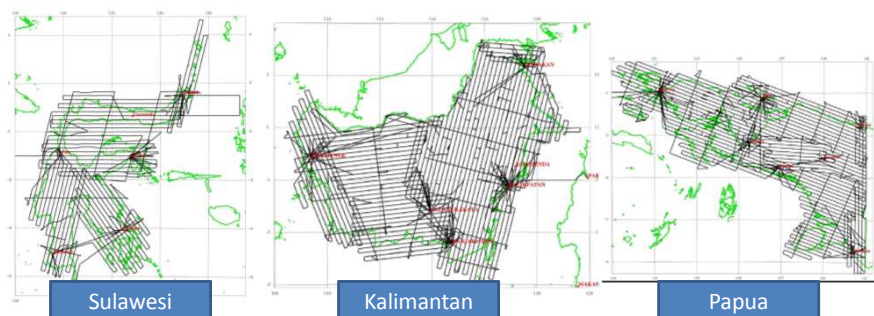


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Height System In Indonesia

- Spirit Leveling → Vertical Control Network → Orthometric Height

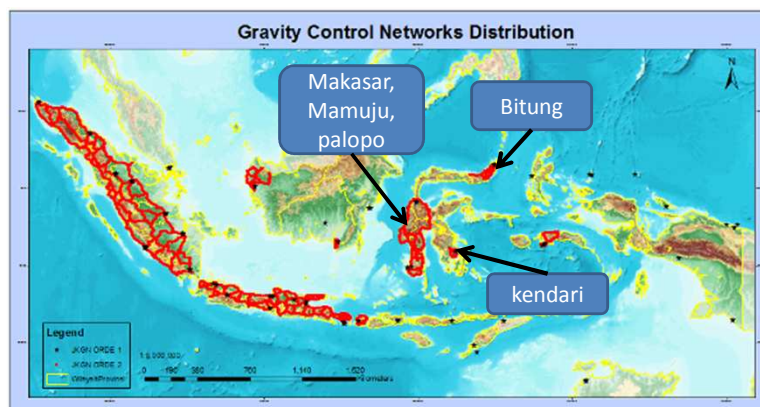


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Height System In Indonesia

- **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 :

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

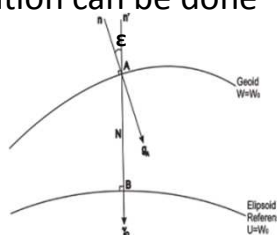


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GRAVIMETRIC GEOID MODEL COMPUTATION METHOD

• Gravimetric Geoid

– Dividing the geoid signals into three components :

- Longwave component → global information → Satellite gravimetry
- medium wavelength → regional information → terrestrial gravity data
- Short wavelength → local information → topography model

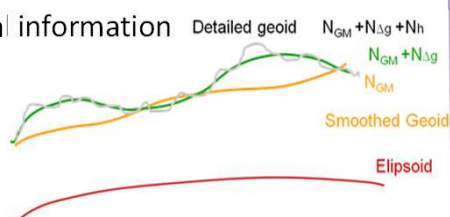


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GRAVIMETRIC GEOID MODEL COMPUTATION METHOD

• Gravimetric Geoid

- The computation steps of the geoid model using remove-restore

$$\Delta g_{res} = \Delta g_{FA} - \Delta g_{GM} - \Delta g_h$$



Remove



Computing the residuals of geoid
FFT Method



$$N_{geoid} = \Delta N_{res} + \Delta N_{GM} + \Delta N_h$$

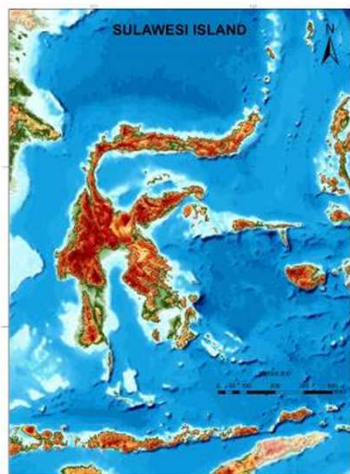


Restore



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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 than 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)

$$N = h - H$$

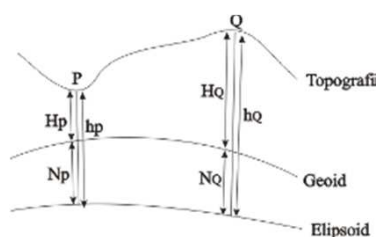
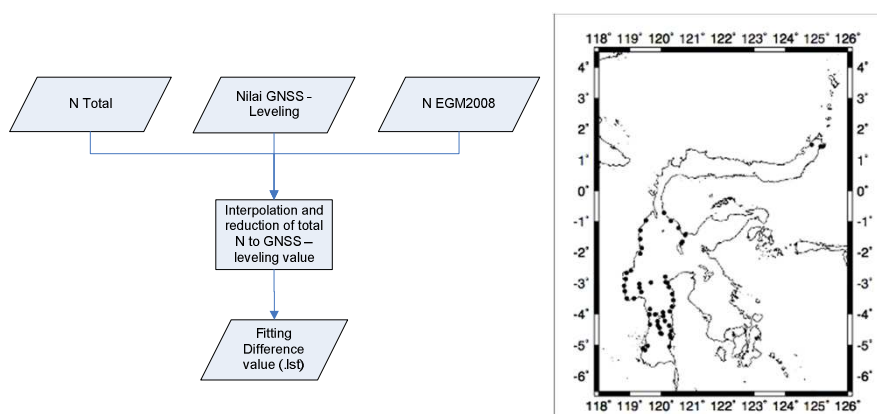


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Geoid Validation

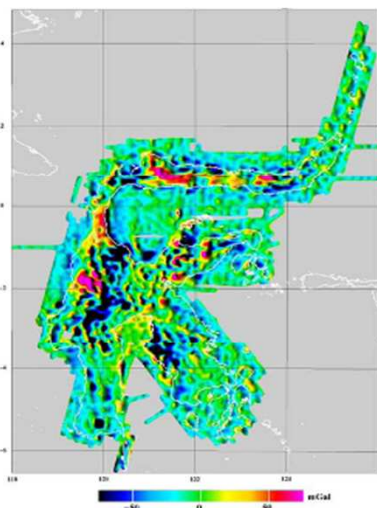


The vertical benchmarks used in the validation were measured **in 2010 and 2013**. As many as 54 points were used to validate the geoid.



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RESULT AND ANALYSIS

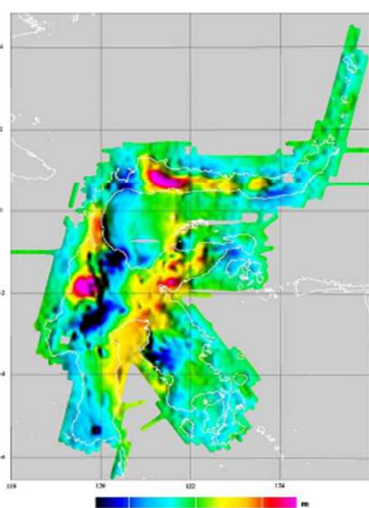


- FAA residual (Anomaly gravity residual)
- FAA deficiency against the global model EGM08 by -60 mgal to 60 mgal
- FAA signals in that range cannot be detected if using only the global model



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RESULT AND ANALYSIS

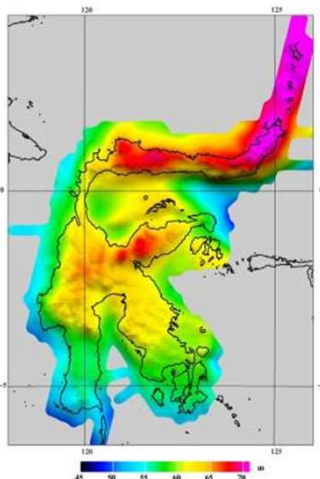


- Geoid residuals in Sulawesi
- The global model is not capable to detect the small variations in the geoid
- The geoid deficiency against the global model EGM08 by -1 meter to 1 meter



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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 southwest to northeast, with the geoid height range between 45-80 meter.



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Validation

- 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

Site	Lat	Lon	N Geometris	N Airborne	N EGM08	N Airborne-N Geometris (Airborne)	N EGM08-N Geometris (Airborne)
713_GPS	-8.2844234	122.2774278	58.788	63.007	64.680	0.791	-1.111
714_GPS	-8.1088402	122.4882888	68.874	53.878	63.121	0.998	0.173
715_GPS	-8.1088402	122.4882888	68.874	53.878	63.121	0.998	0.173
716_GPS	-8.0888216	122.5079922	64.483	59.789	66.077	0.705	-0.488
717_GPS	-8.7786954	122.5182028	57.084	58.379	53.889	0.589	-1.117
718_GPS	-8.9717792	122.5521284	57.086	58.878	58.421	0.891	-0.058
719_GPS	-8.6479987	122.5147381	66.983	63.899	63.711	0.704	-0.883
720_GPS	-8.6479987	122.5147381	66.983	63.899	63.711	0.704	-0.883
721_GPS	-8.5379324	122.5288021	67.017	68.921	63.822	0.899	-1.122
722_GPS	-8.4488912	122.5224891	68.421	65.348	65.714	0.493	-0.887
723_GPS	-8.7786954	122.5182028	57.084	58.379	53.889	0.589	-1.117
724_GPS	-8.8077038	122.4972848	68.719	68.287	63.889	0.482	-0.719
725_GPS	-8.2122668	122.6144661	68.403	63.938	63.838	0.920	0.000
726_GPS	-8.2122668	122.6144661	68.403	63.938	63.838	0.920	0.000
727_GPS	-8.2122668	122.6144661	68.403	63.938	63.838	0.920	0.000
728_GPS	-8.2122668	122.6144661	68.403	63.938	63.838	0.920	0.000
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730_GPS	-8.2122668	122.6144661	68.403	63.938	63.838	0.920	0.000
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800_GPS	-8.2122668	122.6144661	68.403	63.938	63.838	0.920	0.000

	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



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Comparison of airborne gravity N and EGM08 N partially

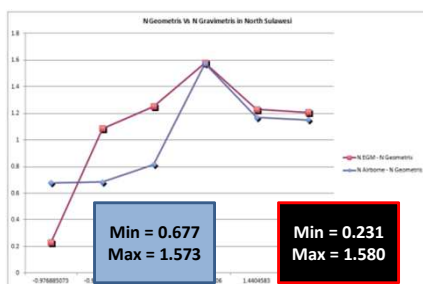
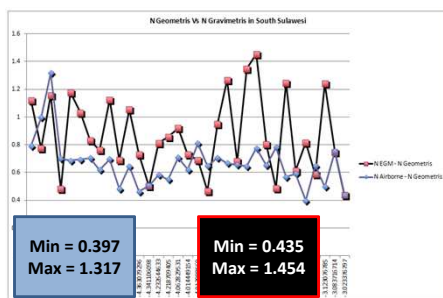
Statistic	N Airborne-N Geometric	N EGM08-N Geometric
	South Sulawesi	South Sulawesi
Average	0.66606367	0.865454579
Stdev	0.16821467	0.279395187
RMS	0.686352336	0.908134238
	Central Sulawesi	Central Sulawesi
Average	0.49514	0.764666667
Stdev	0.166689312	0.524247735
RMS	0.520669369	0.917185052
	North Sulawesi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

Validation

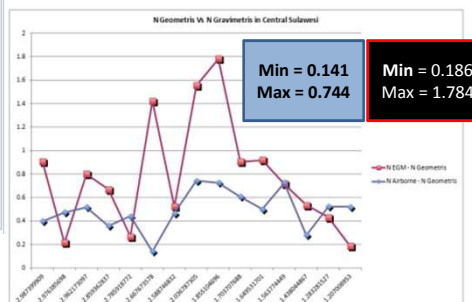
- The gravimetric geoid from airborne gravity measurement can improve the accuracy of global geoid model EGM 2008 by 22 cm in South Sulawesi, 39 cm in Central Sulawesi, and 11 cm in North Sulawesi. While for the island as a whole, the gravimetric geoid from airborne gravity measurement can improve the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