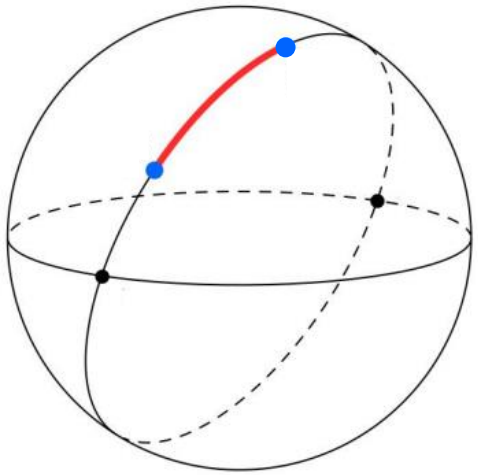
Assessment of Local Geoid in Brunei Darussalam

Muhammad Abdul Hadi bin Haseri

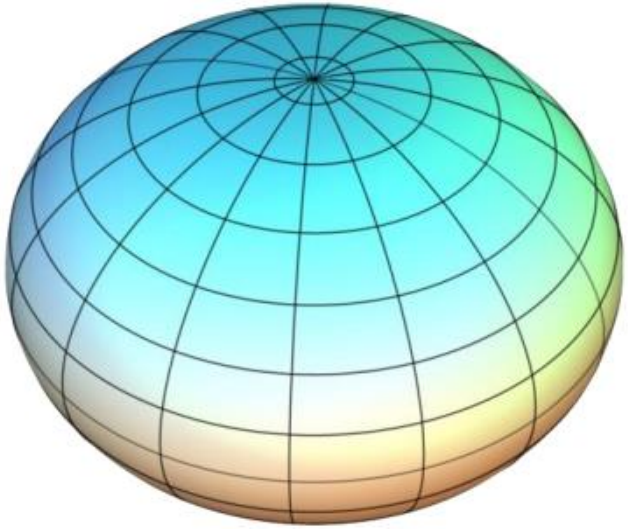
Contents

Introduction

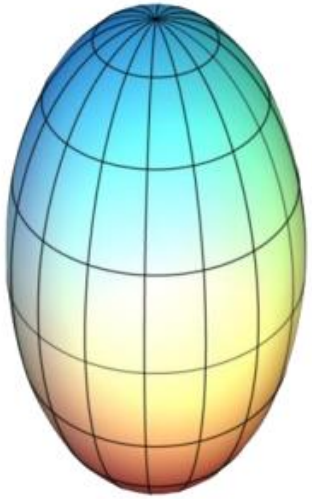
- Shape of the Earth



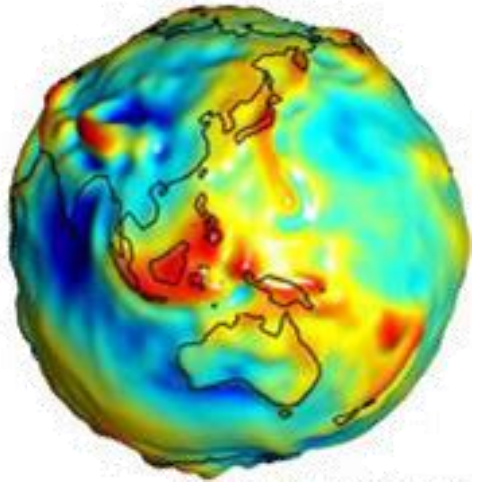
Sphere



Oblate Ellipsoid



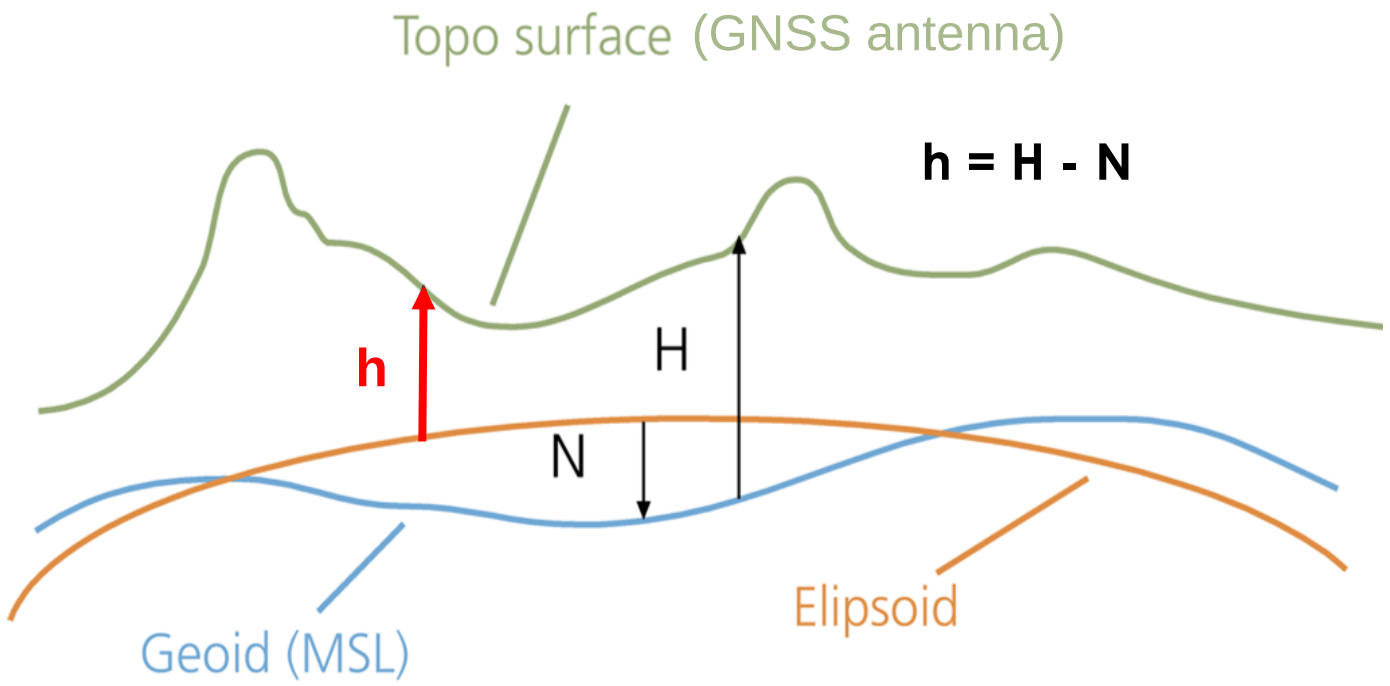
Prolate Ellipsoid



Geoid

Introduction

- Height may be defined as the vertical distance measured to a reference surface.
  - Ellipsoidal Height (H)
  - Orthometric Height (h)
  - Geoid Undulation (N)
- Level surfaces
  - Mean Sea Level
  - Geoid



Background

1948

BT48

MSL for Borneo Triangulation points are not available.

1959

MSL

MSL derived from several tide gauges.

1988

BSD88

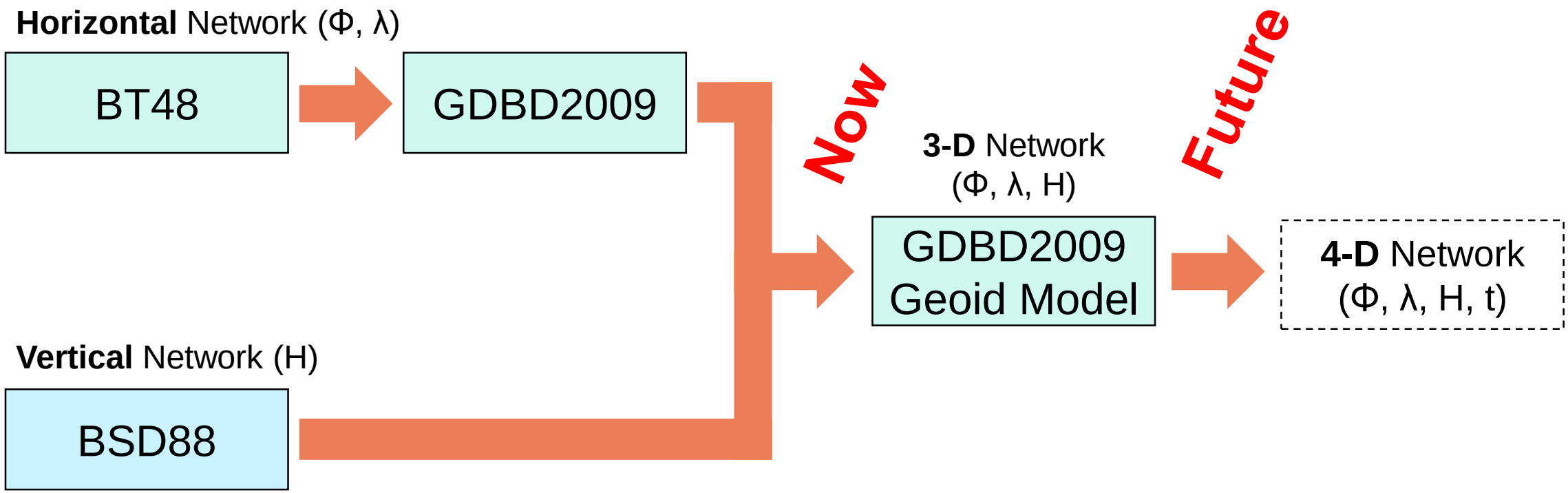
Brunei State Datum is the vertical datum which corresponds to MSL.

2009

GDBD2009

Geocentric Datum of Brunei Darussalam – Local Geoid

Unification of Horizontal and Vertical Networks



Goals & Objectives

Goal

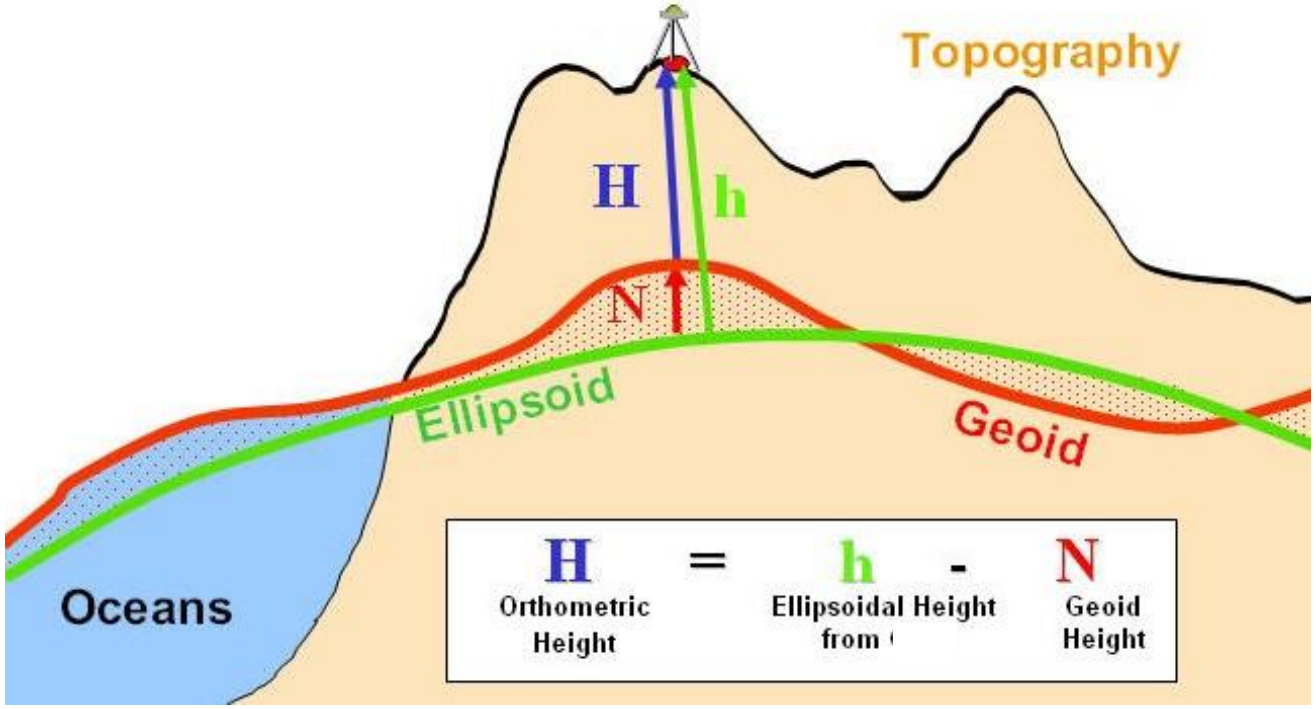
Provide reliable 3D reference frame network

Objectives

- Densify GNSS observations on Benchmarks
- Assess the current Brunei-fitted geoid
- Compute the datum offset between different level surfaces

Methodology

Global Navigation Satellite System (GNSS) - constellation of satellites providing signals from space that transmit positioning and timing data to GNSS receivers – GNSS levelling.



Methodology

Advantages

- Horizontal and vertical networks are connected.
- Datum will be fairy stable.
- Sustainable datum maintenance.
- Compatibility with space-based positioning systems.
- Accessibility of datum via GNSS.

Disadvantages

- Uncertainties in geoid models.
- Accuracy of elevations is limited to the accuracy of GNSS.

Data & Methods

1

Observation Residual

$$VDB = h_{GNSS} - H_{BSD88} - N_{fitted}$$

Where:

h_{GNSS}	Ellipsoidal height
H_{BSD88}	MSL-derived height
N_{fitted}	Brunei-fitted geoid

- Sea Surface Topography
- Geoid is said to coincide with MSL surface.
- Residuals are represented in RMS.

2

Geometric Geoid

$$N_{geometric} = h_{GNSS} - H_{BSD88}$$

Where:

h_{GNSS}	Ellipsoidal height
H_{BSD88}	MSL-derived height

- Assessment continues by deriving geometric geoid.
- Main function is for verifying the Brunei-fitted geoid.

3

Surface Accuracy

$$(x) = N_{fitted} - N_{geometric}$$

Where:

N_{fitted}	Brunei-fitted geoid
$N_{geometric}$	Geometric geoid

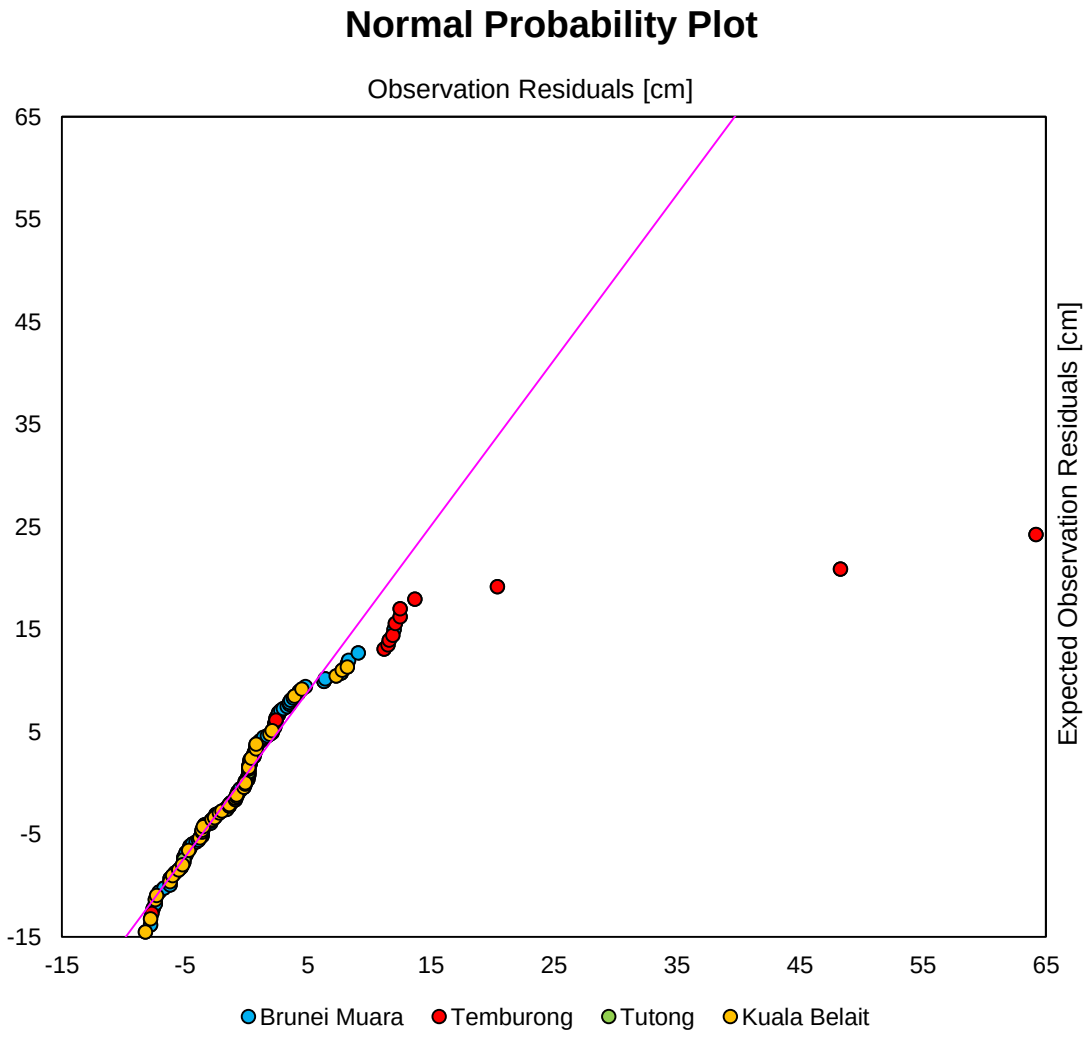
- Depicts the accuracy of the local geoid model in RMS.

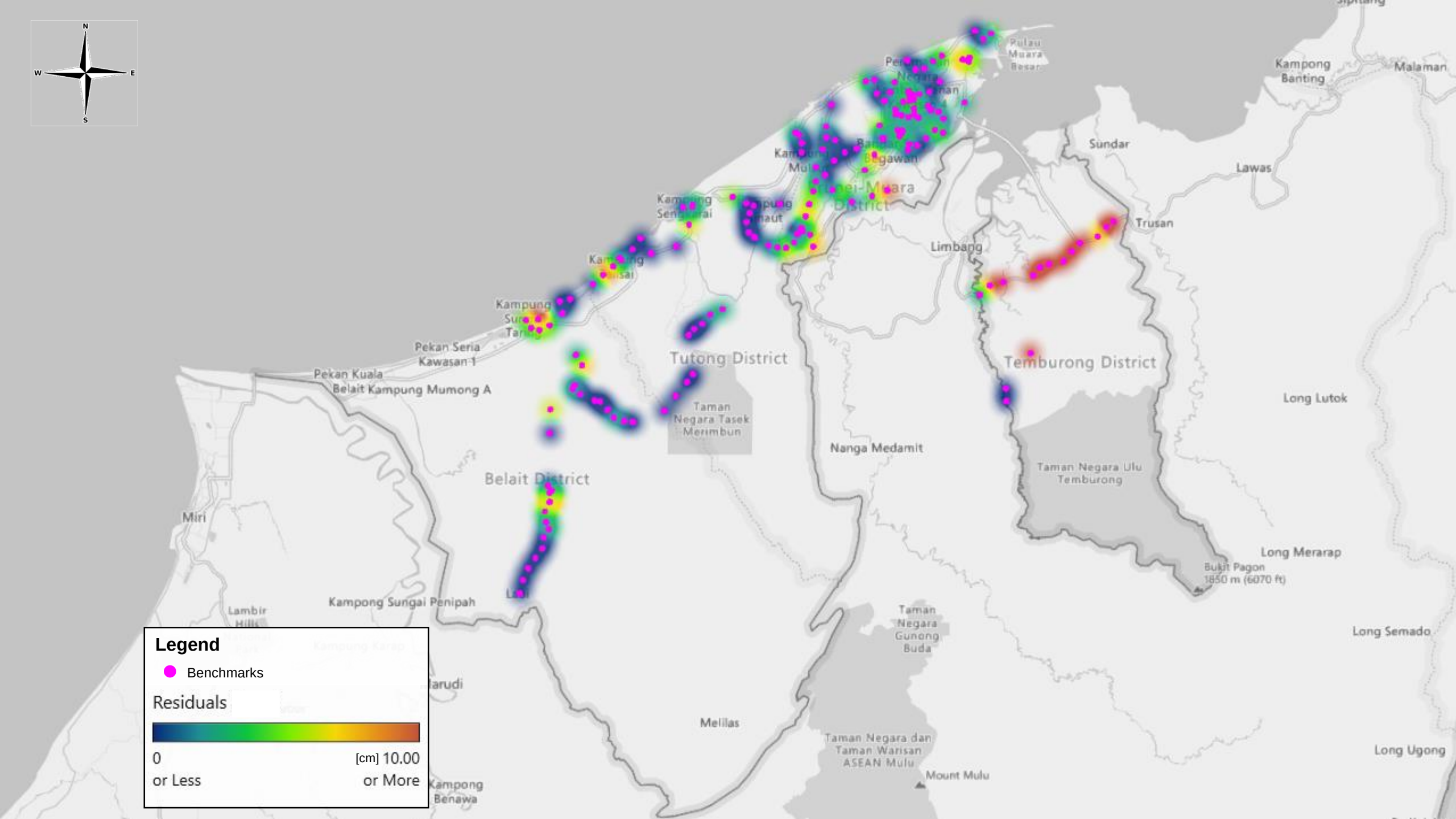
Observation Residuals

$$VDB = h_{GNSS} - H_{BSD88} - N_{fitted}$$

Relative Precision

District	No. of BMs	RMS [cm]
Brunei Muara	99	3.90
Kuala Belait	63	4.13
Tutong	26	2.54
Temburong	17	18.59
Total	205	6.39



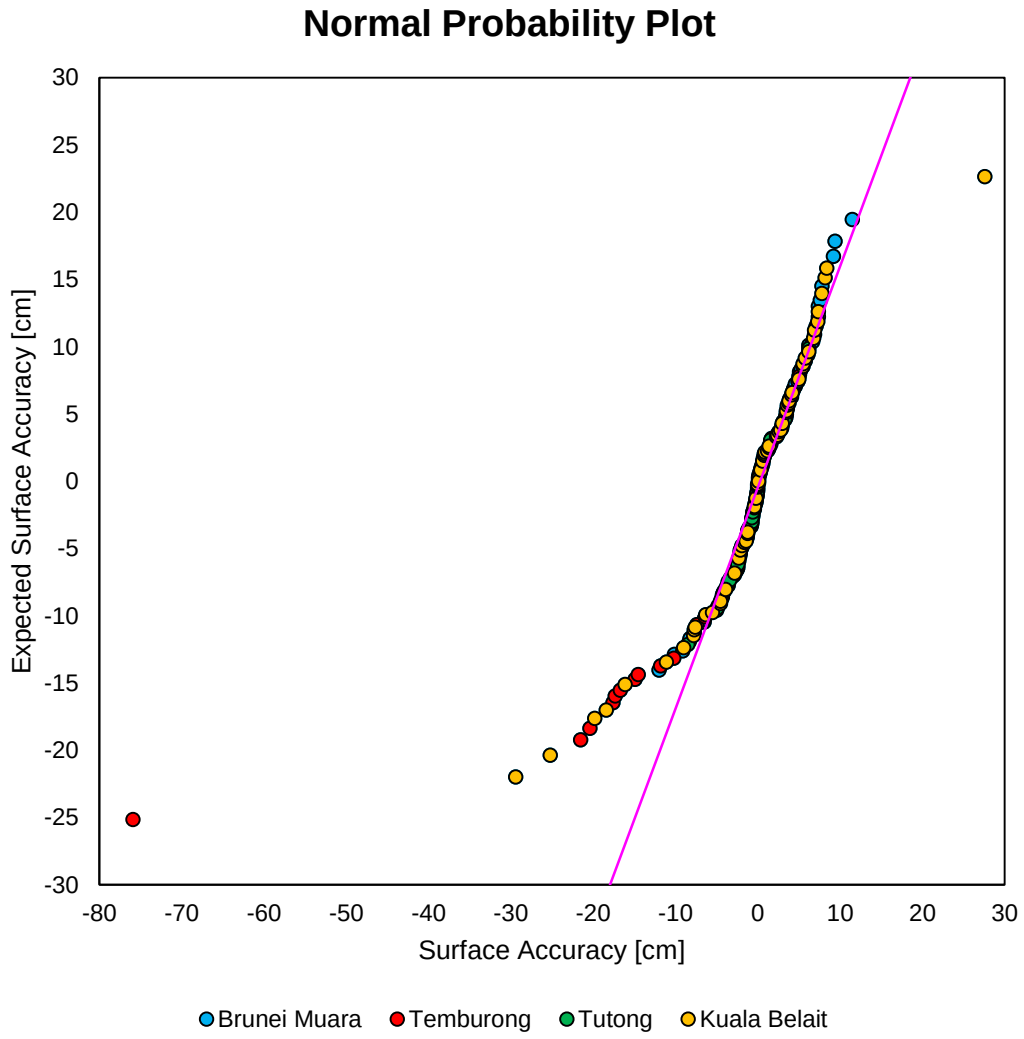

N
W
E
S
Legend
Benchmarks
Residuals
0
or Less
[cm] 10.00
or More
Pulau Muara Besar
Kampong Banting
Malaman
Sundar
Lawas
Trusan
Limbang
Tutong District
Temburong District
Pekan Seria Kawasan 1
Pekan Kuala Belait Kampung Mumong A
Taman Negara Tasek Merimbun
Nanga Medamit
Taman Negara Ulu Temburong
Long Lutok
Belait District
Miri
Long Merarap
Bukit Pagon 1850 m (6070 ft)
Kampong Sungai Penipah
Lambir Hills
Taman Negara Gunong Buda
Long Semado
Melilas
Taman Negara dan Taman Warisan ASEAN Mulu
Mount Mulu
Long Ugong
Kampong Benawa

Surface Accuracy

$$(x) = N_{fitted} - N_{geometric}$$

Relative Precision

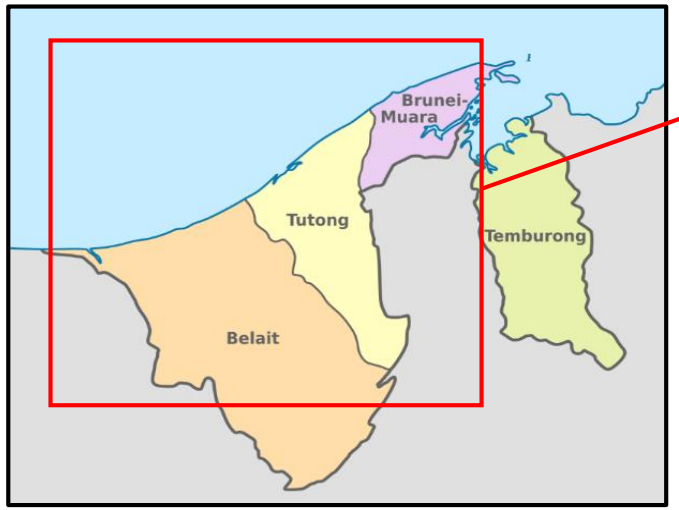
District	No. of BMs	RMS [cm]
Brunei Muara	99	4.43
Kuala Belait	63	8.44
Tutong	26	3.08
Temburong	17	22.14
Total	205	8.56

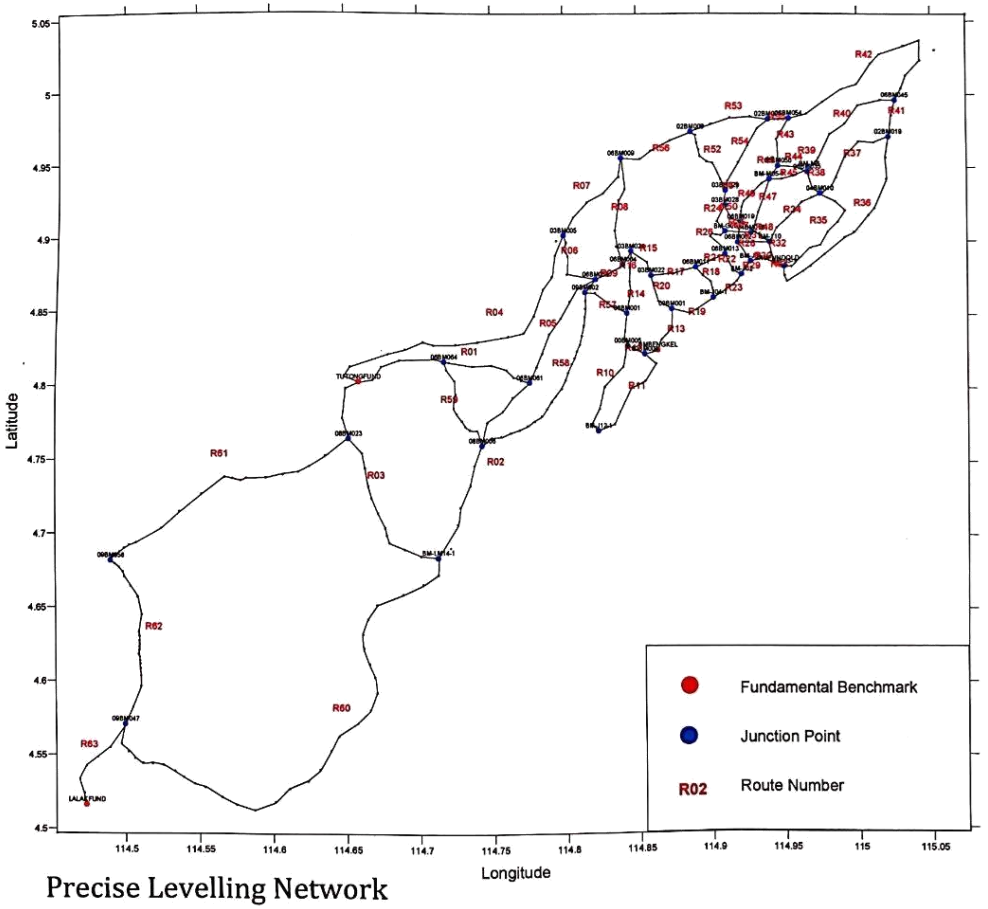


Results & Analysis

Factors affecting accuracy of geoid model:

1. Distribution & no. of reference station
   - Not well distributed
   - No reference benchmarks in **Temburong**;
   - Thus, significantly separation between MSL and geoid level surface of ~22 cm.
   - Generally, other districts are relatively acceptable less than < 4 cm.





Precise Levelling Network

Results & Analysis

2. Accuracy of ellipsoidal height
    - Accuracy is limited to the accuracy of GNSS.
    - Uses error propagation to provide an estimate of the delay resulting from orbit, satellite clock, ionospheric and tropospheric delay (URE) + equipment and environmental errors

Error source	Bias [m]	Random [m]	Total [m]
Orbit data	2.1	0.0	2.1
Satellite clock	2.0	0.7	2.1
Ionosphere	4.0	0.5	4.0
Troposphere	0.5	0.5	0.7
Multipath	1.0	1.0	1.4
Receiver measurement	0.5	0.2	0.5
UERE [m]	5.1	1.4	5.3

Hofmann-Wellenhof, B, et. al. 2008

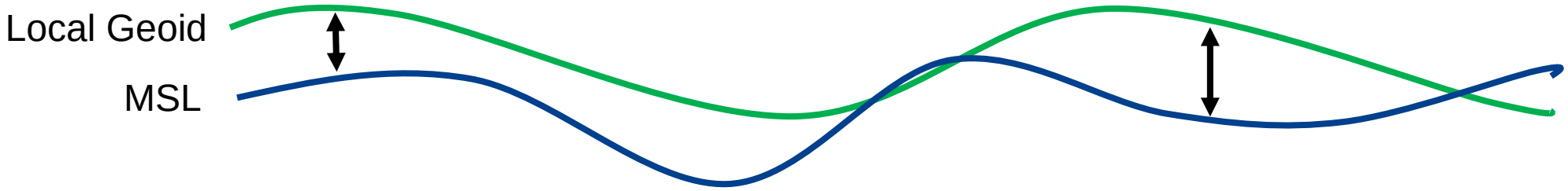
Evaluation

Observation Residuals (Offset)

- In theory, the difference between these values should be zero.
- In practice, using actual observations gives a residual, or measure of misfit between the them.
- As a result, this range is between 2 – 18 cm

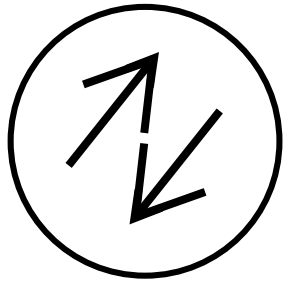
Surface Accuracy

- Accuracy of the local geoid 3 – 22 cm



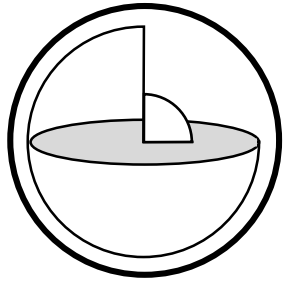
National Datum Development

ITRF2005

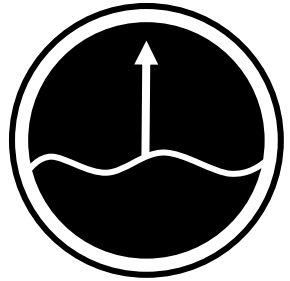


International Terrestrial Reference Frame 2005

GDBD2009

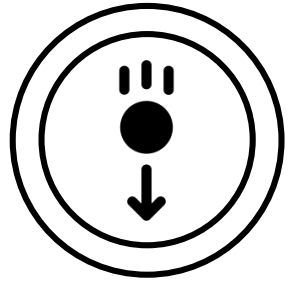


Geocentric Datum Brunei Darussalam 2009



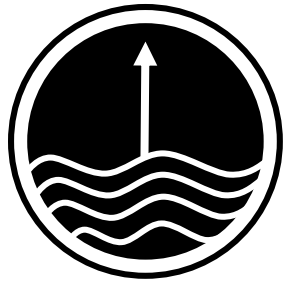
Brunei-fitted Geoid

Gravity Survey



Gravity Survey 2003

BSD88



Brunei State Datum 1988

Conclusion

- **Densify GNSS observations on Benchmarks**
- **Assess the current Brunei-fitted geoid**
- **Compute the datum offset between different level surfaces**

Future Outlook

Further adjustments of local geoid → **Temburong**

Thank You

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