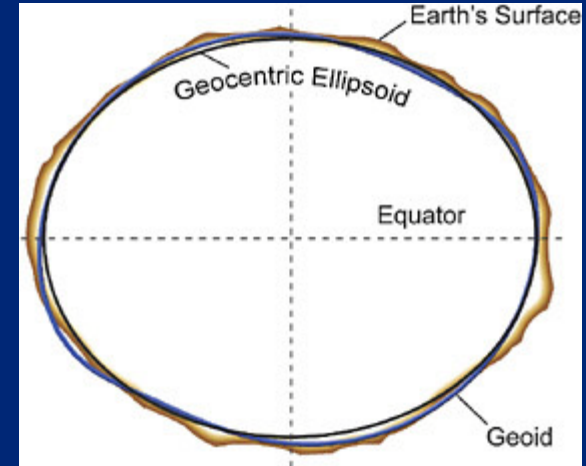
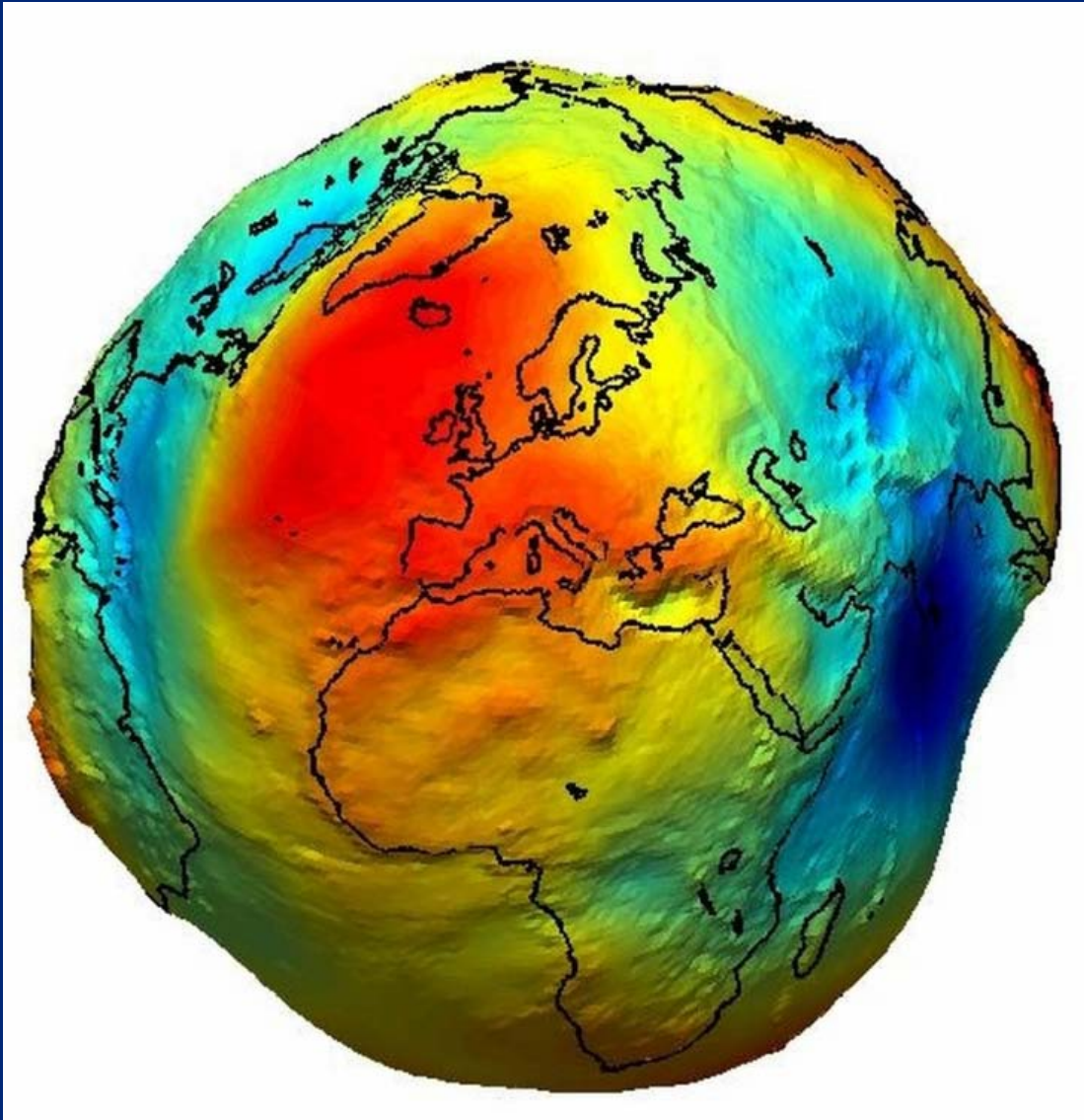


PNG08 - A new geoid model for Papua New Guinea

Richard Stanaway

Quickclose

What is a geoid?



The geoid is a surface approximating Mean Sea Level (MSL)

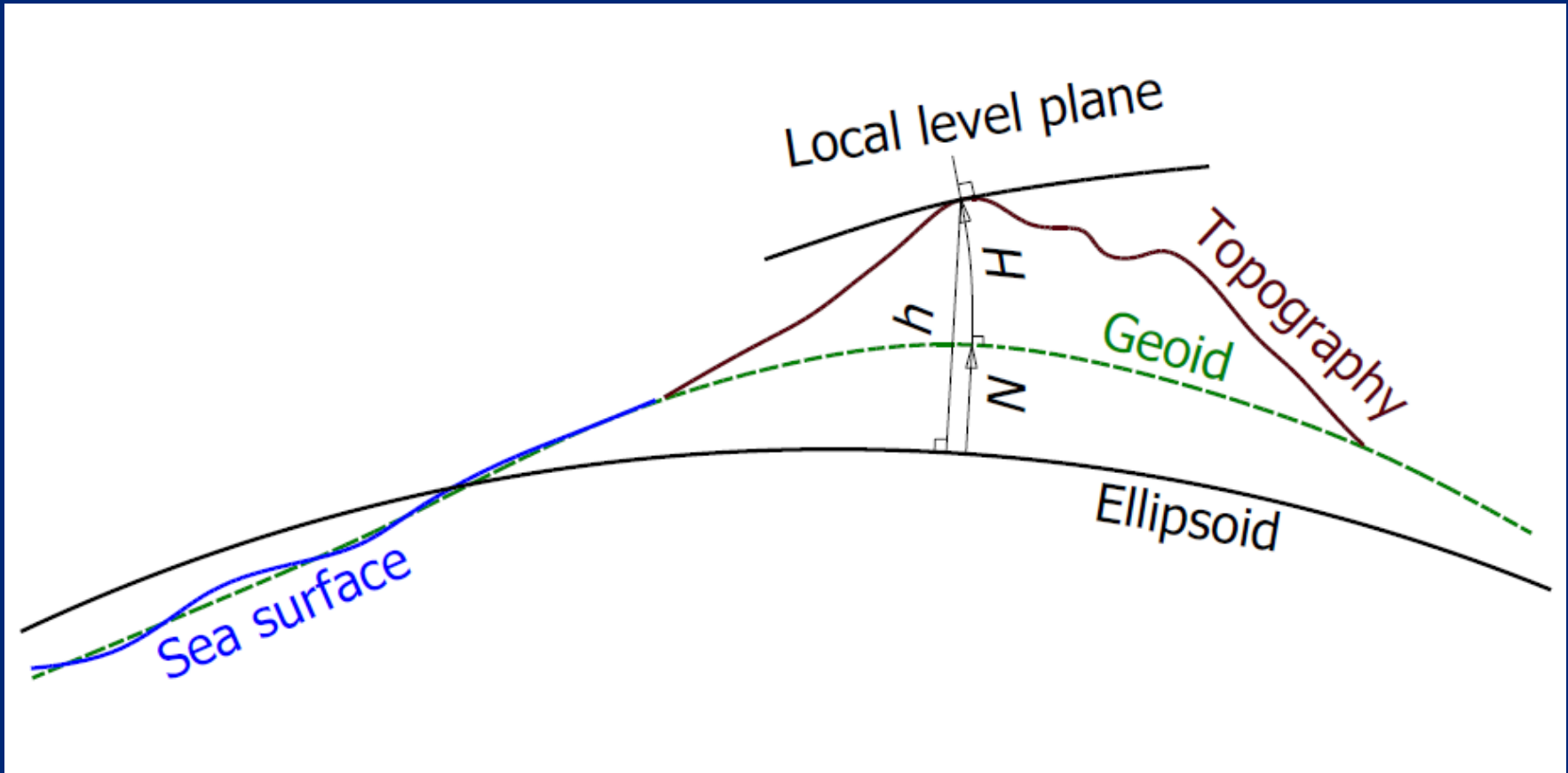
Universität Stuttgart

What does a geoid model do?

- Enables conversion of GNSS/GPS heights (which use the WGS84 or other closely aligned ellipsoid) to approximate Mean Sea Level (MSL)
- The geoid model is the difference between the WGS84 ellipsoid and a geoid approximating MSL (the N value)
- $MSL \approx \text{ellipsoid height} - N \text{ value}$
($H \approx h - N$)

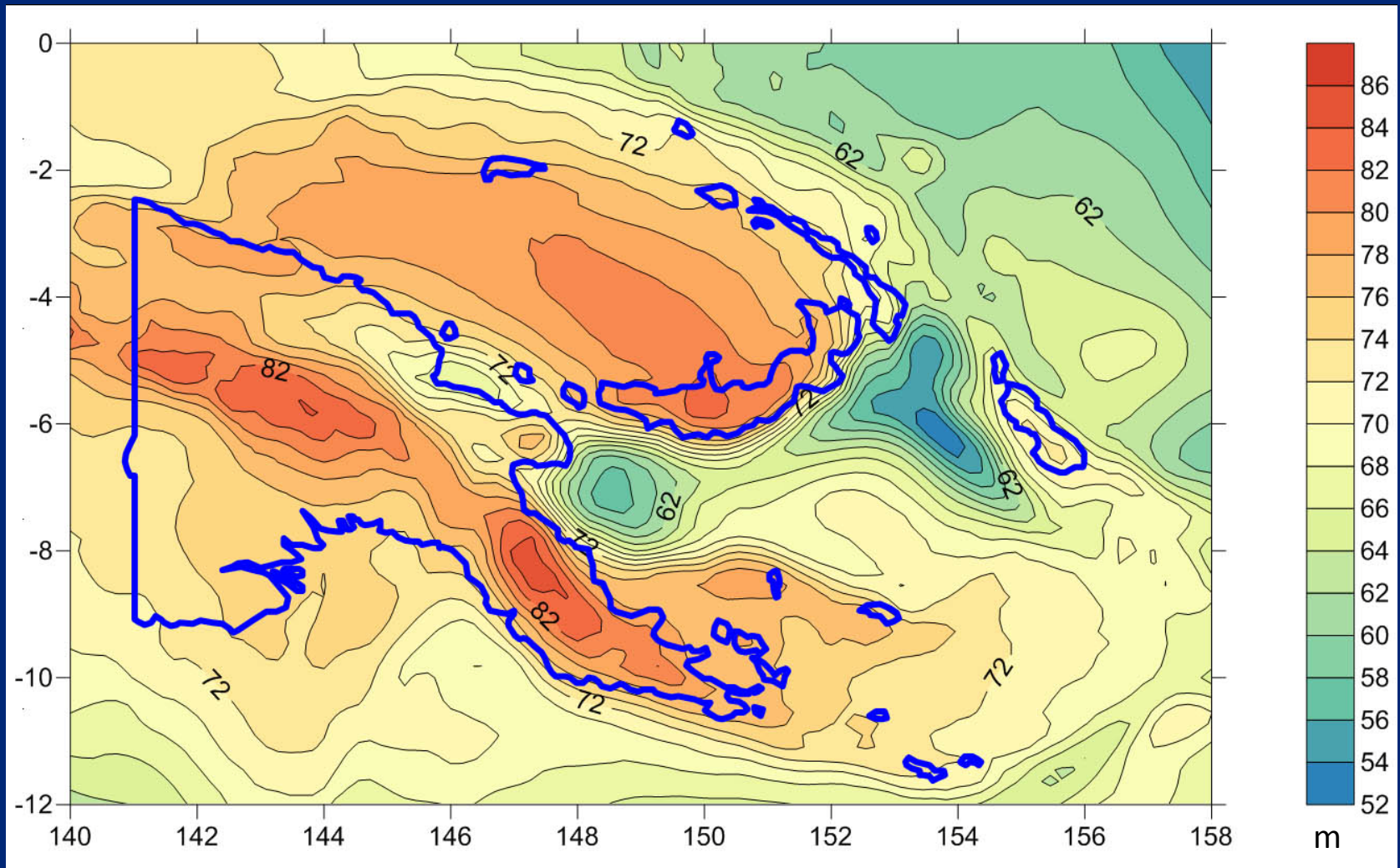
Different geoid models result in different MSL values

The Geoid in PNG – old assumptions



Assumption that the geoid in PNG is coincident to MSL.
We know now that this isn't true.

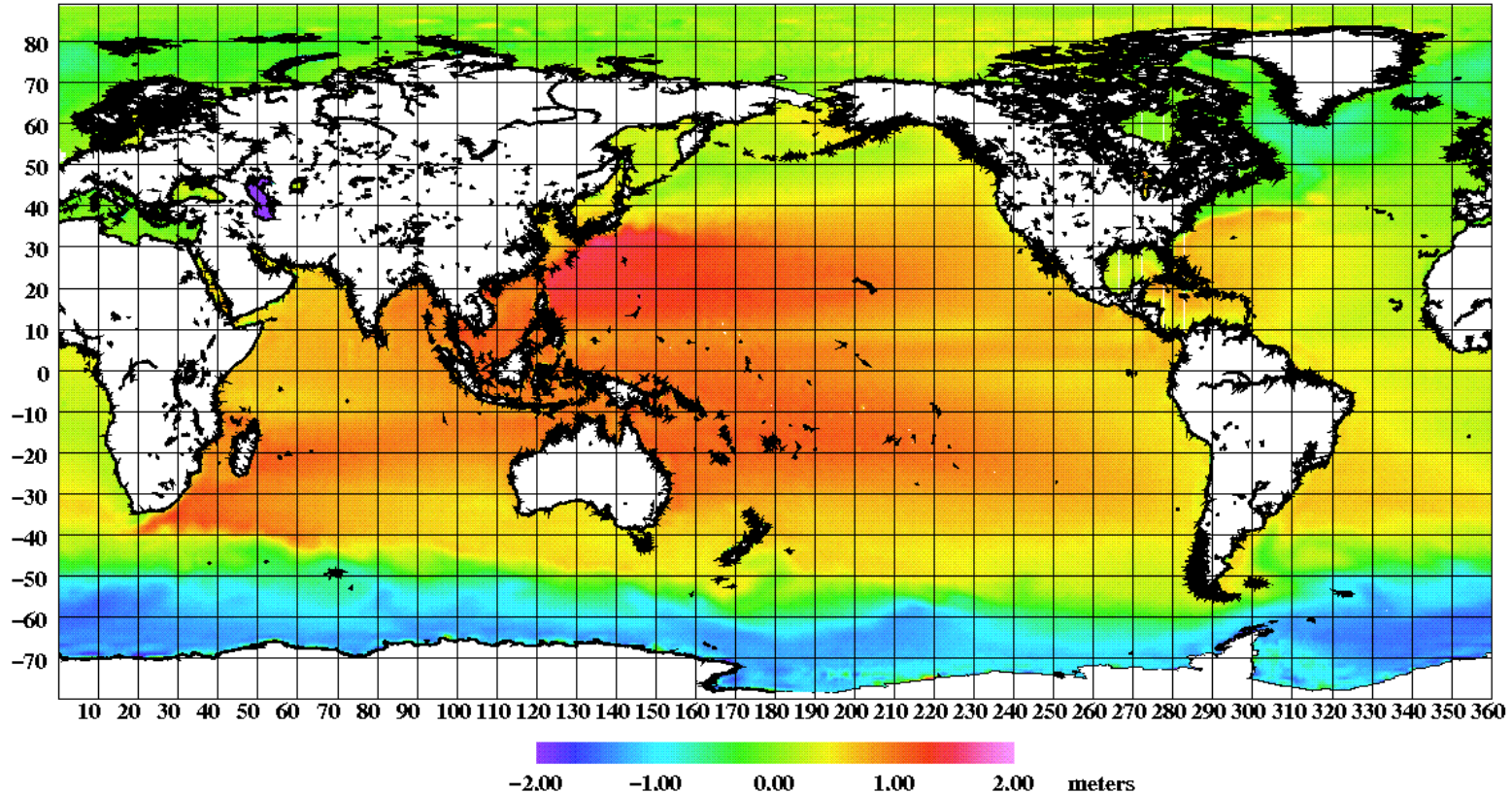
EGM2008 Geoid height in PNG



Plot showing EGM2008 N values over PNG. The geoid in PNG is up to 85 m above the WGS84 ellipsoid .

Height of MSL above the geoid

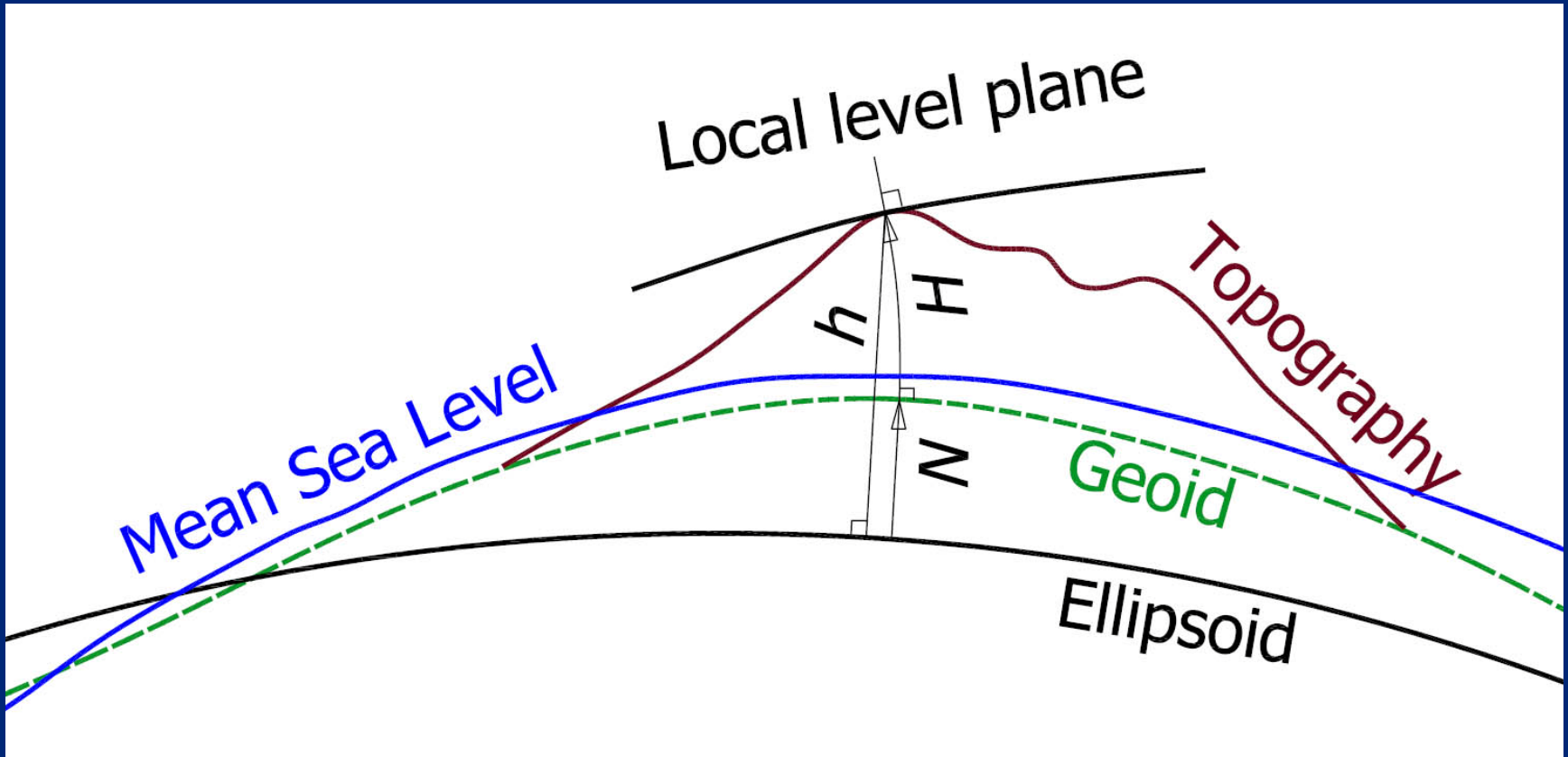
DNOSC07MDT – Mean Dynamic Topography



Technical University of Denmark – National Space Institute

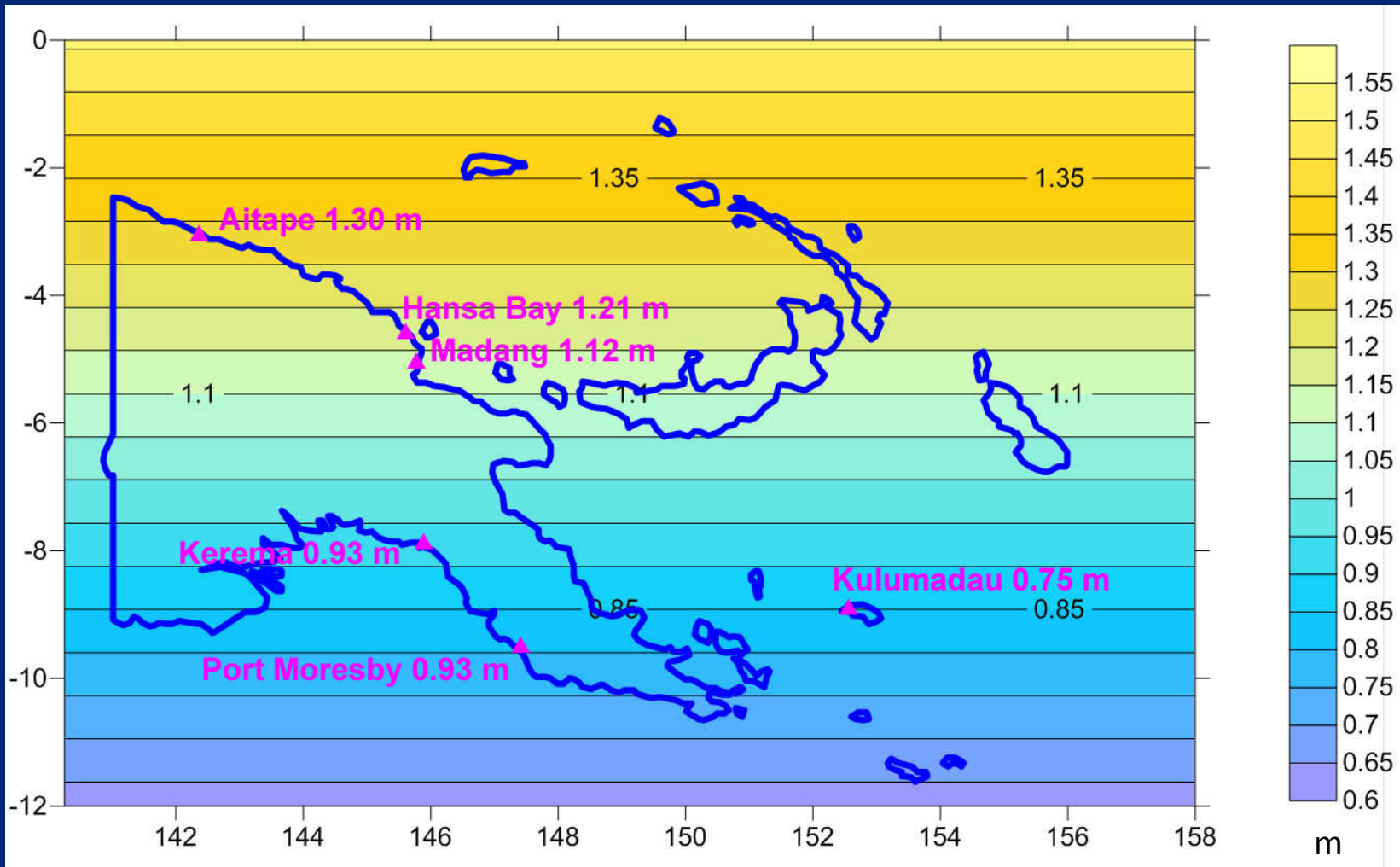
MSL surface is above the geoid in tropical zones due to thermal expansion of the ocean.

MSL geoid difference in PNG



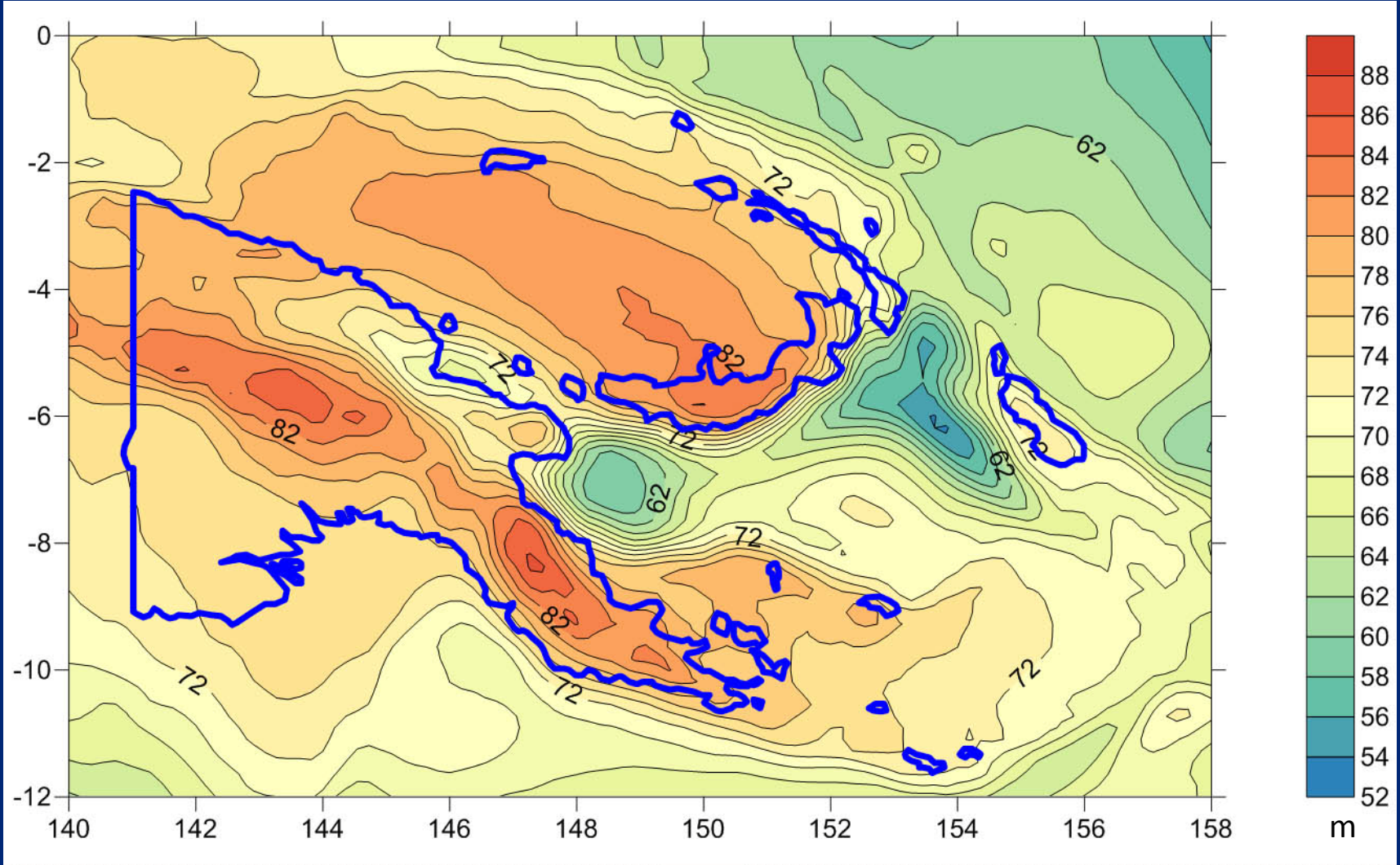
MSL surface is between 0.7 m (Milne Bay Province) & 1.4 m (Manus) above the most recent geoid (e.g. EGM2008).

MSL EGM2008 correction plane to derive PNG08



Sites in purple are tide gauges used to compute the MSL / ellipsoid / EGM2008 offset. The MSL / EGM2008 offsets are shown.

PNG08 Geoid model



PNG08 geoid model accuracy is 0.2 m at 2σ

PNG08 is an interim model until more tidal monitoring is completed

- Requires tidal monitoring at all PNG ports
- Requires cm precise ellipsoidal heights of Tide Gauges
- Stability monitoring of Tide Gauge is required
- Tide Gauges sited away from river mouths
- Lower precision sea surface measurements are still useful especially if made over the full tidal cycle (e.g. by lowering levelling staff or tape from jetty edge)
- Updated MDT model from satellite altimetry can also be used

Station Locator

Lae, Papua New Guinea
147°00'E, 6°45.00'S Type: Tidal reference
8768NM at 93° from station. Meridk
Defined in: harmonics-2004-06-14.t
Region: Austral-Asia
Country: New Guinea

Include in sta

☒ Reference

Text Tides

Lae, Papua New Guinea
Units are meters, initial time

Time	08-13
0.62 12:00 AM	
0.61 12:30 AM	
0.60 1:00 AM	
0.60 1:30 AM	
0.60 2:00 AM	
0.60 2:30 AM	
0.60 3:00 AM	
0.60 3:30 AM	
0.59 4:00 AM	
0.59 4:30 AM	
0.58 5:00 AM	
0.56 5:30 AM	
0.54 6:00 AM	
0.52 6:30 AM	
0.50 7:00 AM	
0.47 7:30 AM	
0.44 8:00 AM	
0.41 8:30 AM	
0.39 9:00 AM	
0.37 9:30 AM	
0.36 10:00 AM	
0.36 10:30 AM	
0.37 11:00 AM	
0.38 11:30 AM	
0.40 12:00 PM	
0.44 12:30 PM	
0.48 1:00 PM	
0.53 1:30 PM	
0.58 2:00 PM	
0.63 2:30 PM	
0.68 3:00 PM	
0.74 3:30 PM	
0.78 4:00 PM	
0.82 4:30 PM	
0.86 5:00 PM	
0.89 5:30 PM	
0.90 6:00 PM	
0.92 6:30 PM	
0.92 7:00 PM	
0.91 7:30 PM	
0.90 8:00 PM	
0.87 8:30 PM	
0.85 9:00 PM	
0.82 9:30 PM	
0.80 10:00 PM	
0.77 10:30 PM	
0.75 11:00 PM	
0.72 11:30 PM	

Text Tides

Lae, Papua New Guinea
Units are meters, initial timezone is AUSES
August 2009 low is 0.1m, high is 1.1m, range is 1.0m.
Predicted historical low is -0.2m, high is 1.4m, range is 1.6m.

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
07-26	07-27	07-28	FQtr 07-29	07-30	07-31	08-01
H0430 0.9	H0437 0.8	H0425 0.7	L0041 0.7	L1047 0.3	L1040 0.2	L1036 0.2
L1152 0.3	L1135 0.4	L1117 0.4	H0326 0.7	H1946 0.9	H2041 0.9	H2305 1.0
H1827 0.7	H1827 0.8	H1842 0.8	L1100 0.3			
L2246 0.6	L2337 0.6		H1908 0.9			
08-02	08-03	08-04	08-05	Full 08-06	08-07	08-08
L1036 0.2	H0045 1.0	H0135 1.0	H0213 1.1	H0246 1.1	H0316 1.1	H0344 1.0
	L1037 0.2	L1040 0.2	L1045 0.2	L1052 0.2	L1101 0.2	L1110 0.2
				H1819 0.7	H1756 0.7	H1750 0.7
				L2029 0.7	L2120 0.6	L2202 0.6
08-09	08-10	08-11	08-12	08-13	LQtr 08-14	08-15
H0409 1.0	H0432 0.9	H0447 0.8	L0015 0.6	L0200 0.6	L0946 0.3	L0935 0.2
L1118 0.3	L1122 0.3	L1119 0.4	H0444 0.7	H0241 0.6	H1914 0.9	H1952 0.9
H1753 0.8	H1801 0.8	H1814 0.8	L1101 0.4	L1023 0.4		
L2242 0.6	L2324 0.6		H1830 0.9	H1849 0.9		
08-16	08-17	08-18	08-19	New 08-20	08-21	08-22
L0942 0.1	H0034 1.0	H0137 1.0	H0222 1.0	H0259 1.1	H0331 1.0	H0358 1.0
	L0959 0.1	L1020 0.1	L1039 0.1	L1055 0.2	L1104 0.2	L1102 0.3
			H1825 0.7	H1759 0.7	H1736 0.7	H1717 0.7
			L2024 0.7	L2104 0.6	L2140 0.6	L2214 0.5
08-23	08-24	08-25	08-26	FQtr 08-27	08-28	08-29
H0418 0.9	H0430 0.8	H0432 0.7	L0003 0.5	L0052 0.6	L1001 0.3	L0959 0.2
L1052 0.4	L1037 0.4	L1022 0.4	H0420 0.6	H0333 0.6	H1834 1.0	H1905 1.0
H1709 0.8	H1712 0.9	H1724 0.9	L1011 0.3	L1004 0.3		
L2249 0.5	L2324 0.5		H1743 1.0	H1807 1.0		
08-30	08-31	09-01	09-02	09-03	09-04	Full 09-05
L0956 0.2	L0953 0.2	H0030 0.9	H0134 0.9	H0214 0.9	H0249 0.9	H0320 0.9
H1943 0.9		L0950 0.2	L0950 0.2	L0955 0.2	L1003 0.3	L1011 0.3
			H1730 0.7	H1657 0.8	H1642 0.8	H1639 0.8
			L2018 0.7	L2055 0.6	L2127 0.6	L2159 0.5

Using *WxTide*
to predict Tides

Computing Ellipsoid Height at Tide Gauges

Static baseline from PNG94 control

or, AUSPOS or NRCan

AUSPOS www.ga.gov.au/bin/gps.pl

NRCan www.geod.nrcan.gc.ca/online_data_e.php

Computing MSL and geoid correction

Compute
RL on Prediction Datum

$$RL_{PRED} = RL_{EGM} + D$$

Compute LAT

$$RL_{LAT} = RL_{PRED} - low$$

Compute HAT

$$RL_{HAT} = RL_{PRED} - high$$

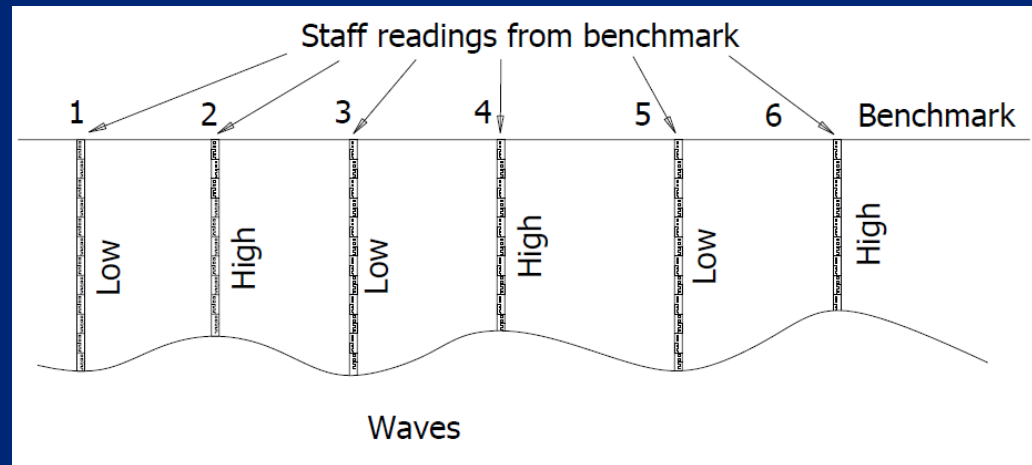
Compute MSL

$$RL_{MSL} = (RL_{HAT} + RL_{LAT}) / 2$$

Compute
correction to Geoid model
(zero order term)

$$C = RL_{MSL} - RL_{EGM}$$

Direct measurements of sea level from a BM



Measurement is average of 3 wave tips and 3 wave troughs within 3-4 minutes

Worked Example

$RL_{EGM2008}$ of BM4 = 3.766 m

PNG Date (2009)	PNG Time (UT +10 hr)	Predicted Height (from WxTide)	Staff Reading (from BM4)	EGM08 RL (3.766 - staff reading)	Predicted minus EGM2008 (D)
May-20	03:00 PM	0.87	2.30	1.47	-0.60
May-20	04:00 PM	0.91	2.28	1.49	-0.58
May-21	09:00 AM	0.57	2.53	1.24	-0.67
May-21	12:00 PM	0.44	2.68	1.09	-0.65
May-21	01:00 PM	0.53	2.67	1.10	-0.57
May-21	05:00 PM	0.95	2.16	1.61	-0.66
May-21	06:00 PM	0.96	2.13	1.64	-0.68
May-21	10:30 PM	0.74	2.34	1.43	-0.69
May-22	04:30 AM	1.21	1.98	1.79	-0.58
May-22	08:00 AM	0.79	2.41	1.36	-0.57
May-22	10:00 AM	0.42	2.78	0.99	-0.57

Mean D = -0.62

$$RL_{PRED} = RL_{EGM} + D$$

$$RL_{PRED} = 3.766 + -0.62 = 3.15$$

Low = -0.20 (from WxTide)

High = 1.80 (from WxTide)

$$RL_{LAT} = RL_{PRED} - low$$

$$RL_{LAT} = 3.15 - -0.20 = 3.35$$

$$RL_{HAT} = RL_{PRED} - hat$$

$$RL_{HAT} = 3.15 - 1.80 = 1.35$$

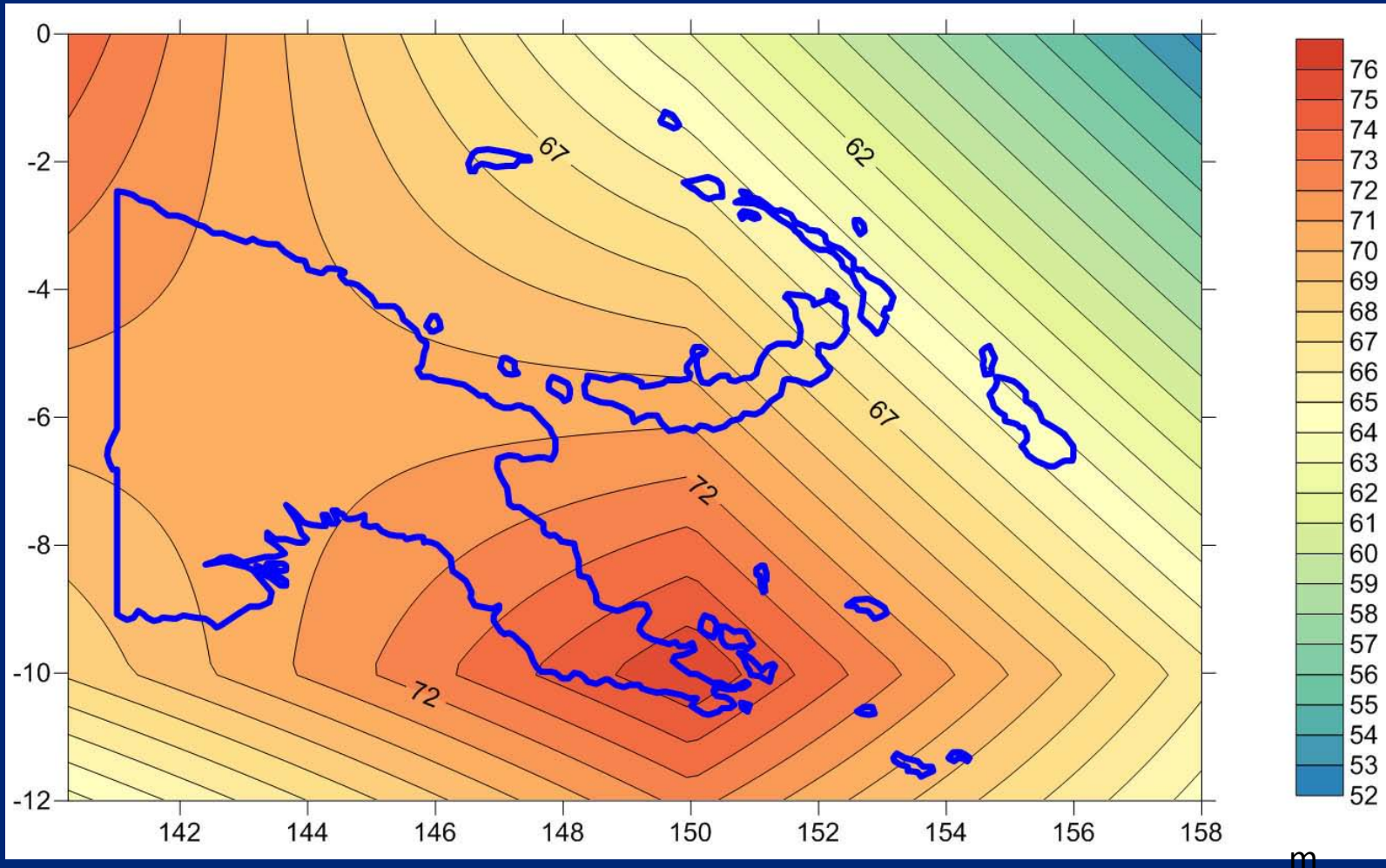
$$RL_{MSL} = (RL_{HAT} + RL_{LAT})/2$$

$$RL_{MSL} = (3.35 + 1.35)/2 = 2.35$$

$$c = RL_{MSL} - RL_{EGM}$$

$$c = 2.35 - 3.766 = -1.42$$

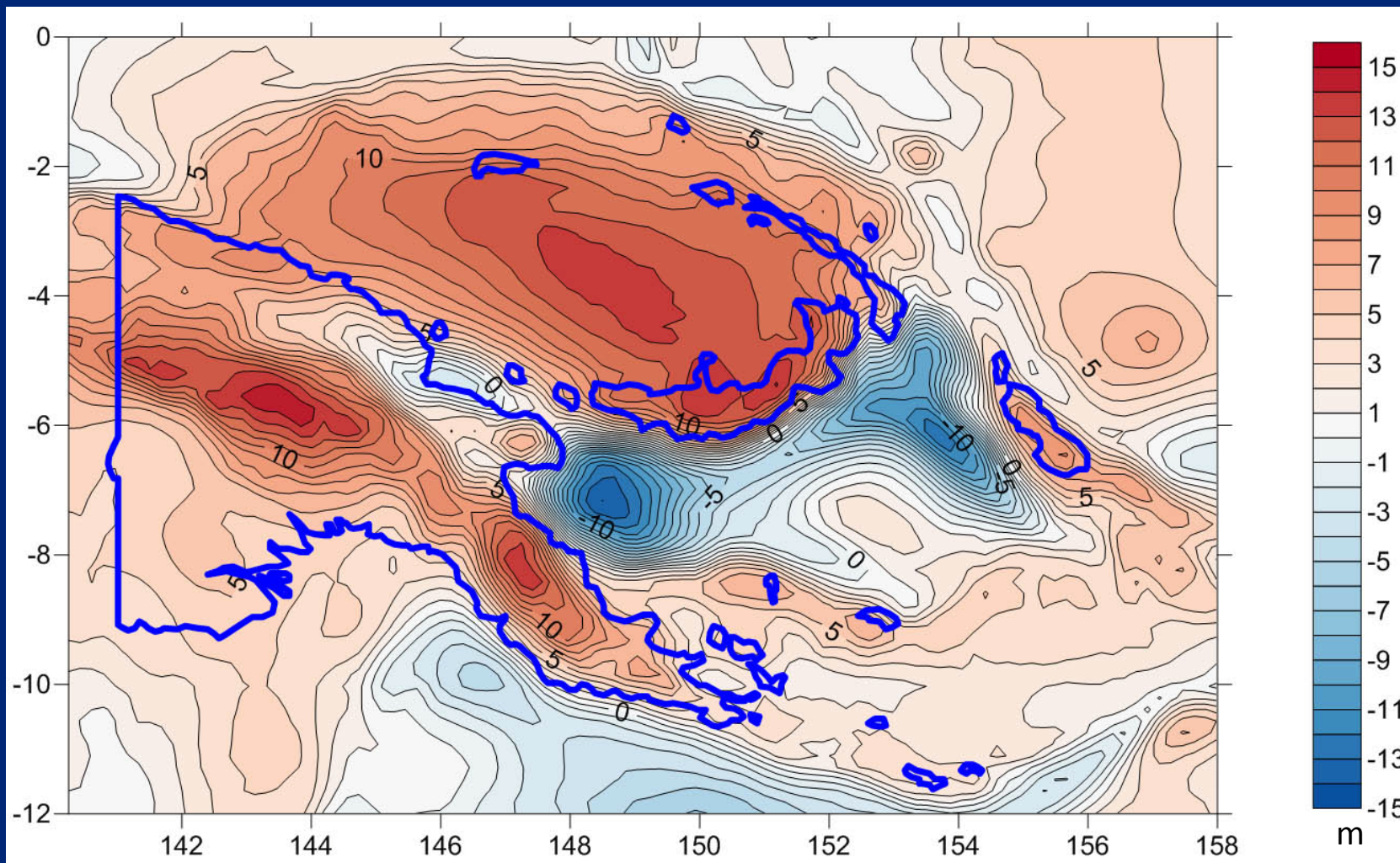
DMA 10°x10 ° Model – UGLY!



This very inaccurate model is still used in many software packages and GPS receivers – e.g. Trimble, Hemisphere, OmniSTAR.

Results in many significant errors in bathymetry and hydrography!

DMA 10°x10 ° Model Error (compared to PNG08)



Errors in heighting of up to 14 metres!! & false gradient of up to 0.2 m / km!!

PNG08 geoid model – where to find it

ASPNG Technical Information - Mozilla Firefox

File Edit View History Bookmarks Tools Help

ASPNG Technical Information

www.aspng.org/techninfovert.htm

The Association of Surveyors of Papua New Guinea inc.

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PAPUA NEW GUINEA

OmniSTAR
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DEPARTMENT OF LANDS & PHYSICAL PLANNING
Office of the Surveyor General

QUICKCLOSE
Software & Geomatics

Papua New Guinea Vertical Datum

Vertical Datums

The predominant height datum in PNG is Mean Sea Level (MSL). Due to the rugged nature of the terrain and inaccessibility of much of the terrain, most of the country has not been connected by conventional levelling networks from a Tide Gauge. Most local realisations of MSL, especially in the Highlands and inland areas have been derived from trigonometric heighting or altimetry. Differences of up to 6 metres between true MSL and local MSL can occur. The recommended approach for height transfer in PNG is to use GPS or GNSS heighting in conjunction with a suitable geoid model. If GPS/GNSS heighting is used on a project where MSL has already been established then the offset between the geoid model and local MSL should be determined.

PNG08 Geoid Model

A new geoid model for PNG (PNG08) has been released on the 14th October 2011.

The new geoid model is derived from the EGM2008 geoid model and was developed by Quickclose Pty Ltd. An offset plane approximating the Mean Dynamic Topography (MDT) of the oceans (the difference between observed MSL and a global geoid model) was applied to EGM2008 and validated by observed offsets between EGM2008 and MSL in PNG. This approach ensures that realistic MSL can now be obtained from WGS84, ITRF2008 and PNG94 ellipsoidal heights. The PNG08 model is a grid of N values (geoid ellipsoid separations) between Latitude 0 and 12 degrees South, and between 140 and 158 degrees East. The model spacing is 2.5 minutes of Latitude and Longitude in WGS84, ITRF and PNG94. Interpolation of the model is by Bi-linear interpolation. The accuracy of the model is 0.2 metres at 1 Standard Deviation.

[PNG08 in text format](#)
[PNG08 in .csv format](#)
[PNG08 in Leica GEM format](#)
[PNG08 in Trimble GGF format](#)
[PNG08 in Topcon GFF format \(yet to be released\)](#)
[PNG08 in Sokkia BIN format \(yet to be released\)](#)

Upcoming Events

46th ASPNG Congress
HIDEAWAY
1-3 August 2012
[More info....](#)

Web-site updates

20th September 2010
2010 Scale of Fees
approved by ASPNG council
[\(Read more...\)](#)

14th October 2011
Luther Sipison
appointed as
Acting Surveyor General
[\(Read more...\)](#)

- ✓ Text format
- ✓ csv format
- ✓ Leica GEM
- ✓ Trimble GGF
- ✓ Topcon/Sokkia GFF format

PNG08 work flow

- Use PNG08 model with GNSS / GPS processing software RTK controller and AUSPOS or NRCan ellipsoid heights.
- $MSL(PNG08) = PNG94 \text{ ellipsoid height} - PNG08 \text{ N value}$
($H \approx h - N$)
- PNG Geodetic database being converted to PNG08
PNG08 update could become gazetted vertical datum
- PNG08 Reduced Levels (RLs) may differ from existing RLs by several metres (e.g. in Highlands, CDW datum, LAT)
(difference should be consistent over local area)
- PNG08 values are within 0.2 m of MSL

What can happen if the geoid model is wrong!



Thank you